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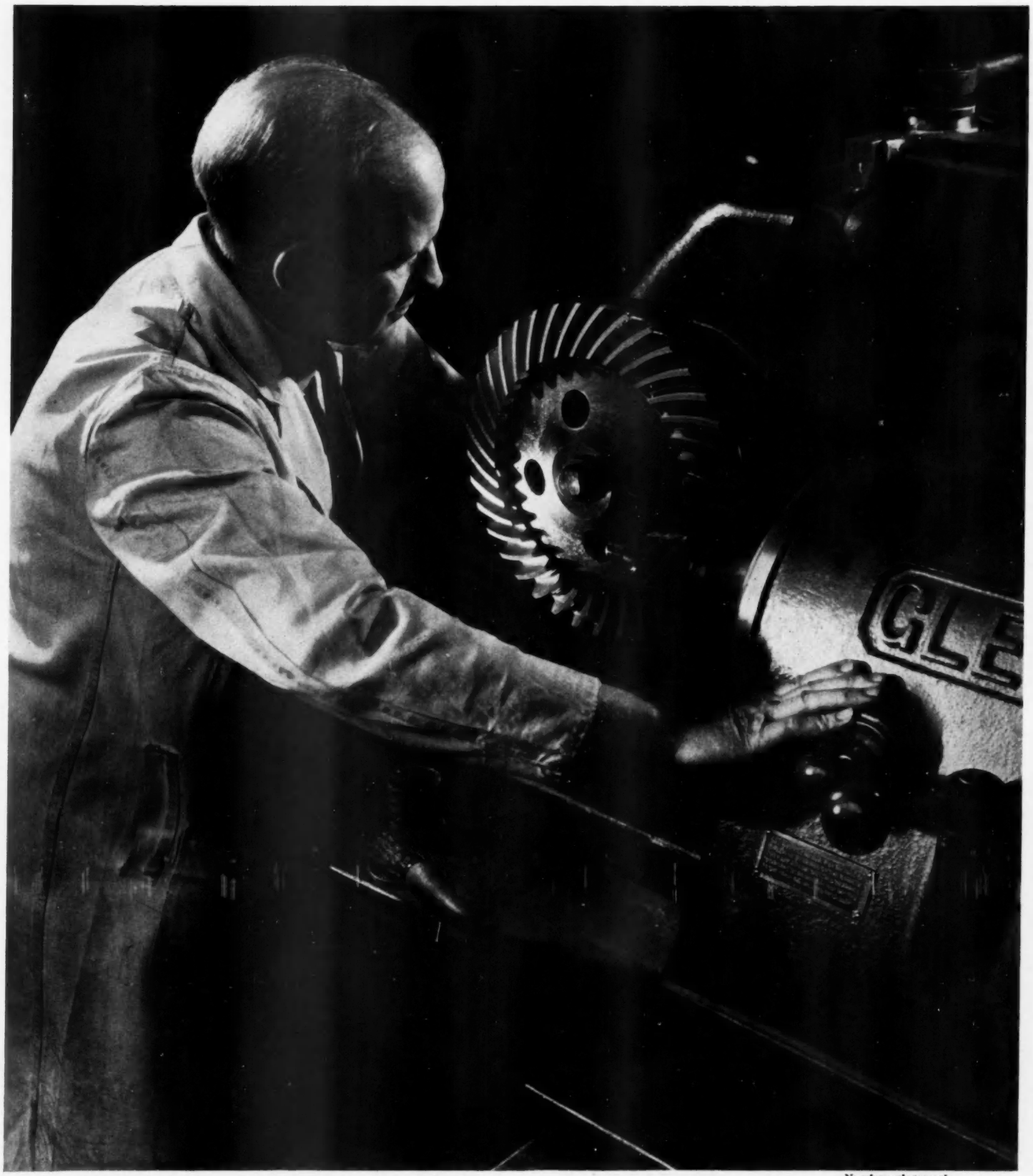

TESTING HYPOID CROWN WHEEL AND PINION

Nurnberg photograph for ENGINEERING

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REVOLUTION IN EUROPE

THE first of a series of special articles on engineering firms in the Free Trade Area appears in this issue of ENGINEERING. Prospects for the Area have taken a turn for the better in the last week or so. The declaration from Paris by the British and French Governments that they are actively concerned to promote such an idea has revived flagging enthusiasm, and the Prime Minister's visit to Dr. Adenauer, the Chancellor of Germany, last week, also brought Western Germany more whole-heartedly into support of the idea, at least so far as official pronouncements go. The fact is, of course, that the Free Trade Area could become a means for Germany to establish a peaceful leadership of western Europe—if industry in other countries is not enterprising enough to take advantage of the large tariff-free market which the area will offer.

There have been baleful tales of the intellectual exhaustion of the negotiators in Paris who have had the task of preparing the text of the Treaty of Rome which establishes, subject to parliamentary ratification, the European Common Market. There is some prospect that members of the Organisation for European Economic Co-operation will have a draft Free Trade Area scheme before them by the early autumn of this year. It is inevitable and right that the European Common Market treaty will provide most of the draft document which will have to be considered for the establishment of the Free Trade Area. This draft will deal with issues of principle and administrative problems and these can be safely left in the hands of professional civil servants and their masters for some months to come.

Meanwhile there is a huge and uncharted sea of speculation to be dealt with regarding the effect of the Free Trade Area on trade and industry. Acres of newsprint have been used on its political and commercial implications but very little that is worthwhile has been written on the impact of the Free Trade Area on individual industries. This poverty of public comment bespeaks a similar poverty of thinking. He who would take a view on the impact of the Free Trade Area on his industry must stick his neck out and dare to be wrong. It is, however, an exercise in which more industrialists must indulge over the next few months.

There have been, of course, the first reactions from trade associations. By and large these have been remarkably favourable. Some comment has been downright optimistic, little of it hostile and a certain amount of it cautious and suspicious. Self-interested as this kind of comment may have been, it provides the main bulk of informed opinion on the subject to date, apart from one or two very good explanatory memoranda of the " glossary " variety put out by such organisations as the Federation of British Industries.

There are two ways in which the impact of the Free Trade Area can be examined from the point of view of individual industries. It is possible to take ten or so criteria and examine the prospects of, say, the engineering industry in the light of each of these in turn and the interaction of all ten taken together. In the event, it may well be better to think in terms of sub-sections of the industry, for what is relevant for heavy electrical generators is unlikely to have much relevance for bicycles and electric kettles. Under these headings the effects of the Free Trade Area on a sub-section might be discussed—ease of access to raw materials, the cost and mobility of labour, comparative transport costs of moving raw materials and end products, capital invested per employee or electric power per employee in different countries, the quality of the management in an industry, the likelihood that different sections of the same industry may move over national frontiers leaving inefficient sections behind to die out, the tactical position so far as tariff disarmament is concerned, the possibilities of gaining markets left by large industries in countries excluded from the Free Trade Area, the possibility of an expanding market in which everyone might gain without additional effort and the weakening effects of cartel organisation from the recent past.

Another way to tackle the problem is to take a specific company in an industry in one country and assess its competitive power in the light of a similar company in another country. For example, it is possible to begin to assess the competitive strength of the electrical engineering industry in Britain compared with an enterprising industry on the Continent. It is possible also to shed some light on the competitive strength of one of the big steel companies in this country by measuring its competitive power against a steel company making similar products on the Continent.

These two methods of approach are really dovetailed in the complicated exercise of assessing the Free Trade Area from this country's point of view. It is necessary to jump from the general to the particular and back again fairly freely. In a series of articles which begins in this issue, we are doing just this. The articles review some important western European companies which might benefit from the Free Trade Area at the expense of British industry under certain conditions. In studying these conditions it is hoped to throw light on the competitive power of their British opposite

numbers. In this way a selective picture will be built up of the impact of the Free Trade Area on British engineering and allied activities. Inevitably, in discussing these particular concerns the broad approach mentioned in the first alternative method will have to be used. Towards the end of the series, articles will be published dealing with the more general aspects under this first alternative method.

The Free Trade Area will be with British industry for many years after any political instrument has been signed. The development of the area as an economic unit will vary in speed, and its implications for different industries will change over the 10 or 15 years of its formative period. This issue of ENGINEERING begins the debate on a subject which will still be controversial when atomic energy is a commonplace.

* * *

Plain Words

It is disquieting to put a great deal of work into providing a service for general use and then to be told that people have never heard of it. An example of this occurred in a recent conference on hydraulic plant in steelworks. Many of the speakers from the floor said either that they had never heard of the facilities offered by the research laboratories operated by the British Iron and Steel Research Association, the Mechanical Engineering Research Laboratory and the British Hydromechanics Research Association, or that they were not aware of the extent of these facilities.

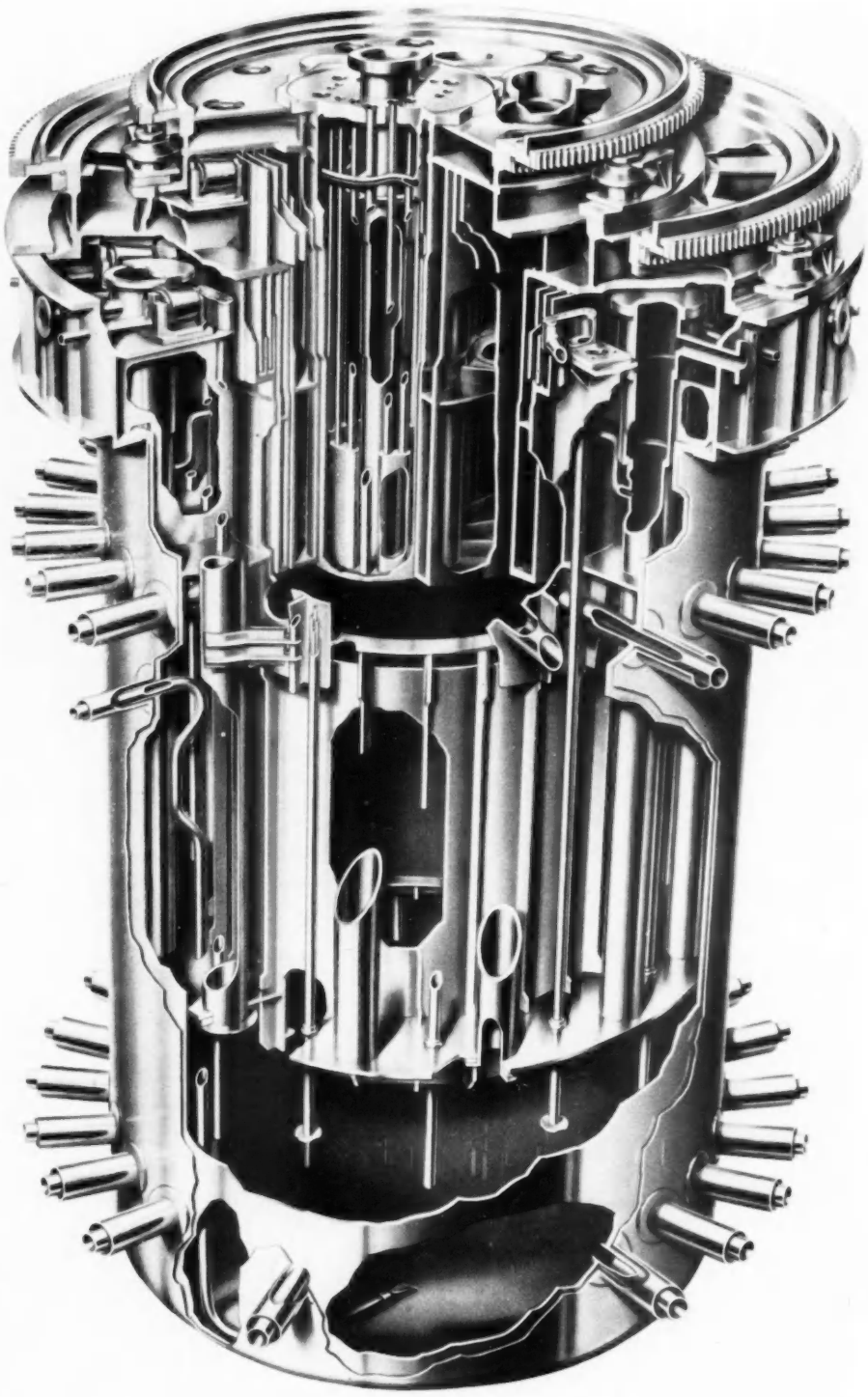
Such ignorance is evidence of a very sorry state of affairs, for the speakers included both the users and the manufacturers of the equipment. How can such a situation arise? Is it want of publicity? Is it publicity directed to the wrong places? Or is it merely a lack of initiative at the receiving end, to look for what is available? The dissemination of news is one of the major problems of the present day, for with the abundance of literature that is distributed to all who are in responsible positions, there is very considerable difficulty in knowing what is important and what can merely be passed on.

This is the problem which all information officers have to face, and one for which there does not seem to be any definite solution. This does not make it any less vital, because in the present days of rapid advance, the progress made in one field may radically affect the plans of manufacturers in quite another field. Even confining the scope to those directly concerned with one particular problem, the difficulty of telling them the latest information still arises.

Historical records include many cases of progress delayed through failures in communication; Mendel's discoveries in genetics had to be rediscovered long after his death before being applied in agriculture and animal breeding. But in an age when learned journals are legion, can there be any excuse for such oversights? Indeed, it may be in the continuous and overwhelming flood of specialist information that the fault lies.

PROSPECT FOR DOUNREAY

A COUNTRY without direct access to nuclear fuels must take great care to use the limited quantities at its disposal to best advantage. To consider the technical aspects of this problem, the United Kingdom Atomic Energy Authority has set up an establishment at Dounreay in the North of Scotland, where a number of studies are already in progress. Dounreay is particularly noted as the site of Britain's first power-producing fast breeder reactor, the containment sphere for which is already a familiar picture. This project by no means exhausts the activities of the establishment, and a materials testing reactor and other facilities are also under construction. In addition, the Authority is providing a site and foundations for the land-based prototype of the Admiralty's submarine reactor. But in a broad sense the entire work of Dounreay may be regarded as devoted to the economic use of nuclear fuels, from efficient chemical processing and fuel fabrication to the breeding of fissile materials. It is a project of



The stainless-steel reactor vessel for the Dounreay fast reactor was fabricated by John Thompson Limited to designs prepared by the Atomic Energy Authority's Industrial Group. It contains the reactor core, breeding blanket, control-rod mechanisms, instruments and liquid-metal coolant.

—MAKING THE MOST OF NUCLEAR FUELS

great significance, not only for Britain, but for the whole Continent of Europe.

Natural uranium comprises only one part in 140 of uranium 235, the fissile isotope capable of sustaining a chain reaction, but uranium 238, which forms most of the remaining 139 parts, and another element, thorium (neither of which are fissile), are also potential sources of heat energy. A breeder reactor is one in which these " fertile " materials are converted into the fissile fuels plutonium or thorium at such a rate that more fuel is created than consumed; in other words, the reactor, which may also serve to generate power, has a " positive gain factor." The term " fast " in this context refers to the speed of the neutrons causing fission and will be discussed again later.

Work of the Establishment

The first stage of the British industrial nuclear power programme has been based on gas-cooled, graphite-moderated reactors of the Calder Hall type. It is expected that these will be followed by liquid-cooled thermal reactors, and then by reactors with a positive gain factor to allow a much higher utilisation of fuel. Research and development work is well in hand on these advanced reactor systems and the purpose of the Dounreay establishment is to investigate the engineering, chemical, irradiation and safety problems of the operation of these reactors on an industrial scale. There are two reactors under construction at present, both of which require considerable ancillary plant. Dounreay Works is the first independent research establishment of the Authority's Industrial Group, whose other establishments, such as those at Springfields, Windscale and Calder Hall, are primarily concerned with making products for sale.

Fast Reactor Group

From the experimental fast breeder reactor, which is concerned with the third stage, will come the operating experience necessary for commissioning an advanced machine, and experimental data on the behaviour of fuel elements, cooling systems, and control techniques. To commission and maintain the reactor in operation, a fuel-element plant is required, together with chemical processing facilities to re-fabricate the fuel into new elements. Recovery of residues and the treatment and storage of active effluent are essential processes in this fuel cycle, to which must be added analytical control in the various plants. New or improved chemical processing methods will form part of the research and development programme. When the appropriate point is reached, the thermal output of the reactor will be linked to a 15 MW electrical generating plant, but the main purpose of the reactor is experimental.

Materials Testing Reactor

The improvement in heat rating of stage 1 reactors, and the development work necessary to implement stage 2, will depend to some extent on irradiation testing of new materials, components and coolant systems. The Industrial Group has sited its first materials testing reactor at Dounreay, which should be operating at full power in April, 1958, and will be devoted to applied research and development for all types of reactor which are direct commitments on the Group. (Similar testing reactors at Harwell, DIDO and PLUTO, will be engaged on longer-term projects.) Work for the civil nuclear power stations, both present and future, will be included in the programme. Initial exploratory tests on fast reactor materials will be carried out in the Dounreay Materials Testing Reactor before final application as complete components in the fast reactor itself. The chemical group at Dounreay will fabricate fuel elements and process these after irradiation, not only for DMTR, but also for DIDO and PLUTO, and British Commonwealth reactors of this type.

Research and development in special reactor experiments are already proceeding in the experimental criticality group on the site. The group is not concerned solely with reactors, but is also responsible for investigating problems of criticality in chemical plants, where fissile materials or their compounds are processed. Thus fluids containing fissile materials are carried in flat slab vessels which, owing to their geometrical configuration, make a chain reaction impossible no matter how concentrated the fissile constituent.

The fabrication of fuel elements using new and improved fuel materials, including plutonium, will be developed not only for the fast reactor, but also for existing and future reactors under consideration by the Industrial Group. The Dounreay Works is thus contributing to stage 3 developments of the power programme by operation and experimental use of the fast reactor, and to stages 1, 2 and 3 by irradiation experiments in the testing reactor. To this must be added applied research and development on fuel elements and criticality problems, which are linked to a wide field of Authority commitments.

Fast Breeder Reactor

The Dounreay fast reactor, which is due to begin criticality trials in April, 1958, has been designed as an experimental breeder reactor to utilise uranium enriched in uranium 235 or plutonium (the conversion product of uranium 238) as fuel in the core and the relatively plentiful uranium 238 or thorium as fertile material in a surrounding blanket. As fissile material is burned in the reactor core, more will be formed in the breeding blanket, and also in the uranium 238 in the core itself. The degree of core enrichment proposed is believed to be in the region of 40 per cent., so that some 60 per cent. of uranium 238 will be available in the core for conversion to plutonium. The total fuel bred in core and blanket will exceed that consumed in the core. The distinction between a fast reactor and a thermal reactor lies in the speed of the neutrons which cause nuclear fission. (Neutrons are also created on fission and it is this fact that makes a chain reaction possible.)

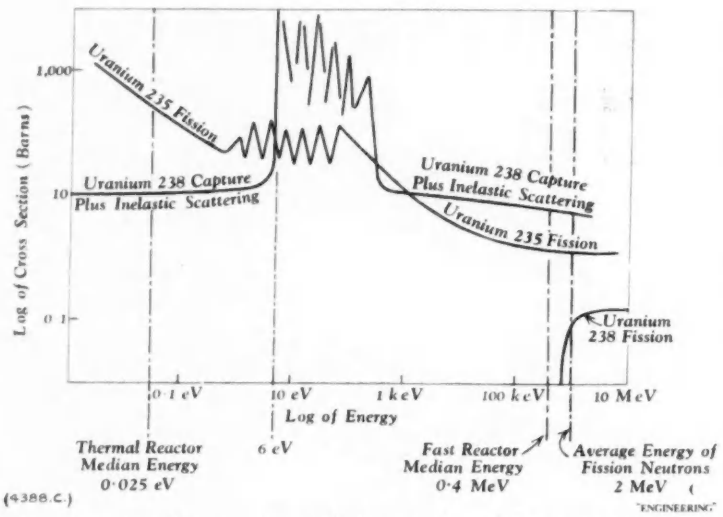
The graphical sketch on page 612, which is much simplified and only intended to illustrate the points in question, may help to convey the distinction. It shows neutron capture and inelastic scattering cross-sections for uranium 238 and fission cross-sections for uranium 235. (Cross-section is a measure of the tendency for a reaction to occur between, say, a neutron and a uranium nucleus, and is measured in barns.)

Dominated by the sphere of the fast breeder reactor, the Dounreay site will also accommodate a materials testing reactor, chemical processing and fuel-element fabricating plants, and various other facilities, including the land-based prototype reactor for the Admiralty's first nuclear submarine.

Neutrons are emitted on fission with an average energy of 2 MeV but lose energy owing to the moderating effect of construction and other adjacent materials. At 0·4 MeV, which is the median energy for a typical fast reactor, it is seen that there is preferential capture in uranium 238, which does not undergo fission at these energies; thus if there is a substantial quantity of uranium 238 present, neutrons will be absorbed and plutonium produced, but there will be no fission neutrons to continue the chain reaction. Consequently all fast reactors use highly enriched uranium. Thus the critical mass, and hence the reactor core, is small, and the problem of heat removal severe, perhaps calling for the use of liquid-metal coolants.

At the thermal end of the graph it will be seen that there is preferential capture in uranium 235, leading to fission, so the presence of uranium 238 matters less. Thus where natural uranium or only slightly enriched fuels are used, a moderator to slow down the neutrons is necessary. There are also intermediate reactors but these will not be considered here.

The advantage of the fast reactor for breeding purposes is its neutron economy, partly because fast neutrons are less subject to parasitic absorption in structural materials: thus there are plenty of neutrons available for converting uranium 238 in the blanket to fissile plutonium, or thorium to fissile uranium 233. Conversion of this kind also takes place in a natural uranium reactor but on a much smaller scale. Certain thermal reactors (the two-region aqueous homogeneous and liquid-metal fuelled systems for example) are capable of breeding but with some-



Simplified plot of uranium 235 fission and uranium 238 absorption and inelastic scattering cross-sections, showing mean energy of fission neutrons, and median energies for fast and thermal reactors.

what lower gain factors. It should be noted that breeder reactors are complementary to other kinds, such as gas-cooled thermal reactors, which may use the plutonium produced; or alternatively provide a source of plutonium for use in the fast reactor core. Indeed, Sir Christopher Hinton said recently that fast reactors may prove the best way of burning the plutonium produced in thermal reactors. A disadvantage of the fast reactor at present, however, lies in the frequent fuel re-processing that is necessary. Thus, in planning a nuclear programme, great consideration must be given to the overall fuel economy.

Nevertheless, the problems associated with plutonium—its tendency towards thermal distortion and difficulties of fuel-element processing—may mean that a plutonium core may not be installed in the Dounreay fast reactor until 1963, about which time plutonium from the early thermal reactors will start to become available.

Hazard

Much has been said of the hazard in operating fast reactors, but such dangers can be avoided by well considered design. The potential hazard is mainly associated with the necessarily high heat rating, and perhaps to the existence of a positive temperature coefficient (the tendency for reactivity to increase as temperature rises) in certain circumstances. Thus if the fuel melted owing to inadequate cooling, it might flow together at the base of the containing vessel to form a super-critical mass so causing an explosion, which though comparatively small would seriously damage the installation. For this reason the vessel is so designed that the fuel on melting would be divided into several different streams. The high heat rating also calls for liquid sodium cooling, a dangerous material chemically (it is highly inflammable and reacts vigorously with water, with which it is associated in the secondary heat exchangers). The eventuality of leakage is well provided for; the lines carrying the sodium are separated by a laminated matrix from those containing water, and the reactor sphere can contain any pressure likely to arise from chemical reaction.

Arrangement of Reactor

The source of power in the Dounreay fast reactor is the fission of uranium 235 and uranium 238 in the reactor core. Since the fast neutron chain reaction cannot be sustained in natural uranium the fast reactor core contains a high proportion of uranium 235, possibly 40 per cent. The reactor core, in which 60 MW of heat can be generated, is 21 in. in diameter and 21 in. high and consists of uranium rods, sheathed in niobium containers, arranged vertically in a closely packed array. Surrounding the reactor core is the breeding blanket comprising about 2,000 rods of natural uranium arranged vertically, each rod being 8 ft. long and 1¼ in. in diameter. Together core and blanket contain some 65 tons of uranium.

The reactor core and breeder are housed in a stainless-steel pot, or reactor vessel, which is 10 ft. 6 in. in diameter and 20 ft. high. Thought to be the most complicated vessel ever fabricated, it has been built by John Thompson Limited, and is illustrated on page 610. Into the top of the reactor vessel is pumped the liquid sodium-potassium coolant which flows down over the core and breeding blanket, thus removing the heat generated by fission and transferring it to a series of concentric-tube type heat exchangers located inside the reactor vault. The sodium-potassium alloy is not the eutectic but a 70/30 alloy; eventually pure sodium may be used since it presents fewer metallurgical problems but for initial operation the low-melting point alloy will be less likely to solidify when the reactor is cold.

The vault is a concrete structure contained in the base of the reactor sphere. It supports the reactor vessel and houses all the heat exchangers and coolant pipework associated with the primary cooling of the reactor core and breeder.

Heat is transferred from the primary liquid-metal coolant to liquid metal in a secondary coolant circuit in the concentric tube heat exchangers, also fabricated by John Thompson Limited. The secondary coolant then passes out of the reactor sphere in stainless-steel pipes to the heat-exchanger house. Here the heat in the secondary liquid-metal coolant is transferred to water in a set of copper-bonded heat exchangers of novel design. The steam produced will eventually be used to drive a 15 MW turbo-alternator located in the turbine hall at the rear of the heat-exchanger house.

The link building adjacent to the heat-exchanger house contains electrical equipment and switchgear primarily for instrument supplies. The Diesel-generator house contains two groups of Diesel-generator sets, one of which supplies electrical power to all pumps and equipment in the main reactor cooling circuits. The second group serves as stand-by electrical capacity for auxiliary reactor plant in the event of a failure of the National Grid supply. On the sea coast about 100 yards from the reactor is the sea-water pump house; in it are four Diesel-driven pumps which supply sea water for cooling the condenser of the 15 MW turbine and also for cooling auxiliary plant in the heat-exchanger house. Control of the reactor is effected from a control room at the end of the administration building. At the rear of the administration building is the element storage building in which new fuel elements are stored and irradiated elements are handled prior to transfer into the cooling pond.

Reactor Containing Sphere

The reactor sphere is 135 ft. in diameter and is constructed from sections of mild-steel plate varying in thickness between 1 in. and 1⅞ in. Generally, the thicker plates have been made from Coltuf 28 steel and the thinner plates to Lloyds P403 specification. In particularly highly stressed areas around the base of the sphere Coltuf 32 steel has been used. All the steel plate used was cold-pressed hydraulically into shape prior to being welded. The sphere has a surface area of about 1½ acres and weighs over 1,500 tons; the total length of the welded seam is over two miles. All the welds were radiographically inspected.

The sphere serves two purposes. Firstly it will localise the spread of fission products formed during reactor operation, should they be accidentally released within the sphere. Secondly, it has been designed to contain any pressure variations that might occur as a result of a liquid-metal fire. Such an occurrence should not increase the pressure inside the sphere by more than 18 lb. per sq. in. or reduce it more than 3 lb. per sq. in. The reactor sphere is, in fact, one of the largest pressure vessels ever built. Access to the sphere is through an air lock 40 ft. long and 16 ft. in diameter with airtight doors at each end; the air lock permits entry to the sphere by way of the adjacent element storage building at the level of the mid point of the sphere.

Shielding

To prevent any radiation hazard inside the reactor sphere the reactor and primary coolant circuits are contained in a concrete biological shield known as the reactor vault. (See ENGINEERING, April 19, page 510.) This reactor vault is in the form of a bowl 90 ft. in diameter and 45 ft. high with 5 ft. thick walls. The roof slab has a central hole immediately above the reactor vessel. Further shielding is provided around the vessel to prevent the secondary liquid-metal coolant and the pipework within the reactor vault from becoming radioactive. This shielding consists of a 4 ft. layer of borated graphite in which an equatorial region of pure graphite permits fission rate measurements to be taken.

Core and Blanket

The fast reactor core is composed of fissile material, in which the majority of the fission processes occur, surrounded by a blanket of fertile material which serves to reflect neutrons back into the core as they try to escape and in which fresh fissile material is generated. The main heat generation occurs in the central portion, the core proper, which is in overall shape, a hexagonal prism 21 in. high and 21 in across the flats, made up of several hundred fuel elements of annular cross-section. Each contains, at boths end, a length of natural uranium which acts as blanket or breeder material. The blanket is completed by surrounding this central portion with approximately 2,000 natural uranium rods 8 ft. long and 1¼ in. in diameter.

When the reactor is operating at its designed power output, the 60 MW of heat generated is removed as already stated by the liquid-metal heat-transfer medium which also cools the blanket. This liquid metal flows down between the fuel elements and blanket elements, and down the inner tubes of the fuel elements. Each element is positioned in, and supported by, the stainless-steel bottom plate of the reactor, while adequate space for the flow of the liquid-metal coolant between the elements is maintained by the fins on each outer can.

The fuel and blanket elements are canned in niobium and stainless steel respectively to contain the fissile material and fission products and to give dimensional stability to the core and blanket lattice. Niobium has a high melting point and a good resistance to hot uranium and sodium. Stainless steel is used for canning the blanket elements, since the conditions are less severe, but it is worth noting that these "less severe" conditions are, in the case of the blanket elements nearer the reactor core, more severe than those experienced by thermal-reactor fuel elements. The neutron flux, and, therefore, the heat generated in the core, is controlled by moving groups of fuel elements into and out of the core, the former movement giving increased reactivity. The fuel elements used for this

purpose are identical to those in the normal reactor charge.

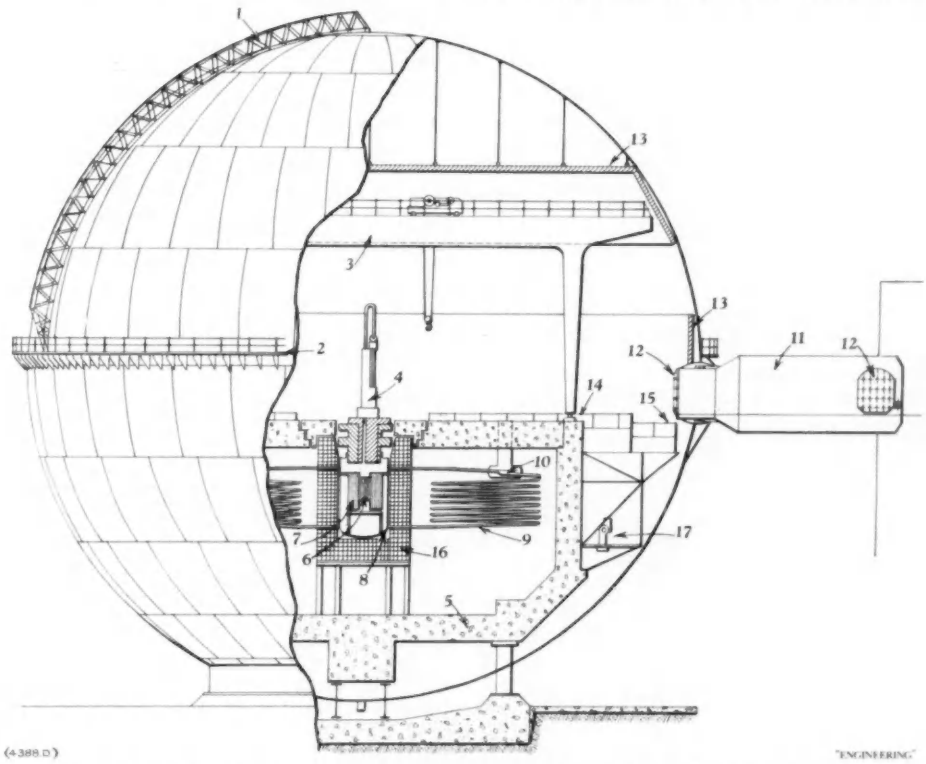
The essential feature of this fast reactor is that it is an experimental tool, and for this reason has been designed so that minor and major components may be easily replaced if different component designs have to be tested. This interchangeability is, in fact, so great that the whole of the assembly within the double-walled reactor vessel can be removed and replaced.

Heat Exchange Systems

The liquid metal to be used initially for heat removal is an alloy of sodium and potassium. It becomes radioactive passing through the reactor, and it is also contaminated by fission products so that it must be contained within the concrete biological shield. Its heat is therefore transferred to liquid metal in a secondary system. This secondary liquid metal carries the heat through the biological shield and out of the sphere to the heat-exchanger house, where the heat is given up in a steam-raising plant. Any steam generated in excess of the turbine requirement spills automatically into dump condensers cooled by sea water. These can absorb the full reactor heat output if the turbine is not running. The liquid metal is circulated by electromagnetic pumps having no moving parts, the only maintenance required being upon the insulation of the windings. The windings can be removed without opening the liquid-metal system; in the primary system this is effected by remote operation through the biological shield. The system contains no valves, nor any other part requiring mechanical maintenance.

Complete failure of the heat-removal plant would very quickly result in overheating of the reactor, and to prevent such a failure the heat removal is shared among twelve independent and identical units. A unit comprises two primary liquid-metal circuits, one secondary liquid-metal circuit, a steam raising plant and a dump condenser. Each unit has an independent electrical supply from its own Diesel alternator so that the risk of a large-scale electrical failure is remote. If, in spite of the above precations, a widespread failure of heat-exchange plant occurred, it would not be sufficient to shut down the reactor, because some heat would be generated by fission product activity after shut-down. A thermal-syphon system of heat removal is provided which uses no electrical power but relies solely on convection effects to dissipate heat to the atmosphere. Convection causes a circulation in the primary liquid-metal system from which heat is transferred to liquid metal in the thermal-syphon system. This liquid metal is also circulated by convection and transfers its heat to the atmosphere through heat exchangers in the stack. The system also dissipates a certain amount of heat during normal running.

The heat exchangers which transfer heat from the primary coolant circuits to the secondary circuits are all of tube and annulus design. Since the liquid metal reacts violently with water, the steam-raising exchanger has been designed to prevent leaks from one side to the other. Stainless-steel tubes carrying the liquid metal and the water are bonded in a common copper matrix which allows a leak of either fluid to escape to atmosphere. Apart from the heat exchangers the twelve steam-raising plants are similar in design to conventional forced-circulation boiler systems.



General arrangement of the Dounreay fast reactor. Enclosed in a 135 ft. diameter steel sphere the reactor will produce more fissile material than it consumes and evolve some 60 MW of heat. The electrical output will be 15 MW.

1. Rotating access ladder
2. Windgirder
3. Rotating crane
4. Charge machine
5. Concrete vault
6. Reactor core
7. Breeding blanket
8. Reactor vessel
9. Primary heat exchanger
10. Electromagnetic pump
11. Air lock
12. Air-tight doors
13. Acoustic blanket
14. False floor
15. Lifting floor
16. Graphite shield
17. Fan gallery

Charge and Discharge Facilities

Fuel elements in the reactor must be periodically discharged, because, firstly, prolonged irradiation causes physical distortion of the elements and secondly, the fuel-element efficiency falls due to depletion of the fissile material and the build up of fission products in the element. Similar considerations apply to a lesser degree for the breeder elements. The elements are therefore removed periodically from the reactor in shielded containers and placed in the cooling pond to await chemical processing. New or refabricated elements are loaded into the reactor in their place.

Removal of elements from the reactor presents a number of problems because: (1) the elements are extremely radioactive; (2) the elements are immersed in liquid metal which becomes radioactive after irradiation in addition to being chemically active; (3) the elements continue to generate heat for a considerable time after the reactor is shut down because of residual fission-product activity; and (4) the blanket gas above the liquid metal in the reactor is highly contaminated with radioactive fission products and cannot be allowed to escape into the sphere atmosphere.

To overcome these problems a charge machine has been designed for removal and replacement of elements. This machine is lowered on to a seal door on the rotating shields above the reactor vessel, and elements are moved vertically in or out of the reactor using the charge machine. The charge machine is heavily shielded to avoid any radiation hazard to personnel. Embodied in the machine is a cooling system for removing residual heat from the elements after withdrawal from the liquid metal. At the base of the machine a gas-tight door is fitted and this is interlocked to ensure that it and the corresponding seal door on the rotating shields are closed before the charge machine can be removed from the rotating shields, thus preventing direct escape of blanket gas into the sphere. When an irradiated element has been raised into the charge machine, the machine is transported by the large rotary crane to the canning station at the side of the reactor vault.

Reprocessed elements are returned from the chemical plant to an element store in the element storage building. When required for use the elements are put in a stainless-steel can filled with inert gas and raised into the canning station in the sphere. The charge machine having discharged an irradiated element into the canning station now re-loads with a re-processed element and is transported to the rotating shields where the re-processed element is lowered into the reactor.

Provisional Details of Dounreay Fast Reactor

Thermal output	60 MW
Electrical output	15 MW (with all power passing through turbines at 25 per cent. efficiency).
Fuel	Enriched uranium (approx. 40 per cent. enrichment).
Canning	Niobium (finned) for core; stainless steel for blanket.
Elements	21 in. long with reflector top and bottom.
Element support	Bottom end only in stainless steel plate; elements fluted to allow passage of coolant.
Element assemblies: core	21 in. high, 21 in. across flats (hexagonal prism).
blanket	8 ft. high (approx. 2,000 elements 1¼ in. in diameter).
Total weight of uranium (core and blanket)	65 tons.
Reactor vessel	20 ft. high, 10 ft. 6 in. in diameter.
Coolant	70-30 sodium-potasium alloy. (melting point 45 deg. C.).
Primary coolant reactor outlet temperature	380-400 deg. C.
return temperature	180-200 deg. C.
Drop from primary to secondary circuit	30 deg. C.
Secondary coolant temperature drop	Less than 50 deg. C.
Coolant pumps	Flat linear induction pumps (electromagnetic).
Pressure drop across pump	20 lb. per sq. in. (circuit is maintained at excess pressure to prevent pumps from "panting" due to their thin walls; thin walls are used to minimise electrical losses).
Power consumed	120 kW in group of four pumps (2 in. primary and 2 in. secondary circuit).
Nitrogen blanket (above coolant in pressure vessel) pressure	50 lb. per sq. in.
Initial steam conditions	200 lb. per sq. in. abs. and 80 deg. C. of superheat.
Cooling water flow (two pumps)	50 million gal. per day.
Containing sphere	135 ft. diameter.

Previous references to the Dounreay fast reactor have appeared in ENGINEERING on August 26, 1955 (vol. 180, page 280), August 3, 1956 (vol. 182, page 157), October 19 (page 506), December 7 (page 735), March 8, 1957 (vol. 183, page 315), March 15 (page 345), and April 19 (page 509). A discussion of some of the nuclear principles involved was published last March 29 (page 411).

To be continued

Weekly Survey

Cover Picture: *Hypoid gears, used to connect skew (offset) shafts, resemble a true hyperboloidal gear and are generated by rotating circular cutters. As for all gears, a high load capacity depends upon a long uniformly stressed line of contact. The picture shows a pair of hypoids being inspected for good meshing and the absence of high spots.*

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In Search of Adventure

Britain is supplying skilled manpower to the world, and particularly to the Commonwealth, to a far greater extent than she is receiving it. In the past six months there has been a striking increase in the number of people seeking to emigrate. Since the war more than 1·2 million people have left Britain, mainly for Australia, Canada, the United States and New Zealand. An analysis of the emigration statistics, and of those for immigration, has been made by Political and Economic Planning (P.E.P.) in a broadsheet entitled *Britain and Commonwealth Migration.*

P.E.P. do not attempt to uncover the reasons for the exodus of British people from their country. A proper examination of motives "would need an intensive field inquiry carried out over a period of years." The authors of the broadsheet do suggest that some of the emigrants seek a higher standard of living overseas. This has, historically, been the mainspring of most emigration from most countries. Recent statements on the wishes of the Hungarian refugees showed that they too wanted the higher standard of living they believed the United States could offer. The same motive which takes Britons to Canada and the United States brings to Britain people from western and eastern Europe, Africa, the West Indies, India and other countries. But there are other motives—including the desire to escape the rigours of the British climate as well as those of British taxation; the feeling that life here is to-day much less secure than formerly. Others are "stirred by a spirit of adventure or by the alternatives of a different way of life for themselves and their families." This is, of course, a motive which leads people from other countries to come to Britain. On balance, however, more go out than come in, and "the drain on skilled manpower is heavy."

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A Decade of International Development

The International Bank for Reconstruction and Development began operations in 1946 but it has in fact just completed a decade of activity since its first loans were made in 1947. Over these years it has made 166 loans amounting to 3,006 million dols after allowing for cancellations and refunding. These advances have been made in 44 countries and overseas territories.

Its early activities were concentrated in Western Europe and in its first year 500 million dols. were lent to France, the Netherlands, Denmark and Luxembourg. Since that date another 576 million dols. has been loaned in Europe making a total of 1,076 million dols. Since 1948 the bank has extended its activities to under-developed territories mainly to finance electric power supply, transportation, agriculture and industry. Over the years it has lent 1,930 million dols. in such areas so that there is a slight predominance of loans made to the under-developed territories.

Outside Europe the largest recipient of assistance has been Latin America, where 65 loans amounting to 703 million dols. have been made, the largest beneficiaries by far being Brazil, Mexico and Colombia in that order. In Asia 34 loans worth 565 million dols have been made of which no less than 224 million dols. has gone to India. A long way behind at 77 million dols. comes Pakistan closely followed by Japan at 76 million dols. Australia has had 6 loans valued at 318 million dols. Africa has had 15 loans amounting to 347 million dols. most of which has gone to South Africa and the Rhodesias and Nyasaland. It is thus apparent that although the amount of funds going to the under-developed areas has been increasing, the areas which have the most developed administrative machinery for using the facilities of the Bank have in fact received proportionately more than those under-developed territories which are lacking not only in capital equipment but also in administrative and managerial ability. Asia is still in much the worst position if the money is measured on a per capita basis. The fact is, of course, that it is not sufficient to have underdeveloped resources and the will to use them. The skill to use them and the organisation to channel skilled manpower and finance must be available to gear enthusiasm and natural resources to economic development.

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E.P.A. Under New Management

From July 1 the European Productivity Agency, which has previously been financed from American funds through the International Co-operative Administration becomes a charge on the member countries. The United Kingdom has promised to provide £150,000 a year for three years as its share. America and Canada will contribute to particular parts of the Agency's programme. The relationship between E.P.A. and the member countries is for the most part carried on at official level, and the Agency programme is organised under eight main headings covering management, social factors, technology and applied research, industrial problems, agriculture, economic factors, marketing and problems of under-developed areas.

Up to now British industry can hardly be said to have been wholehearted in its participation in E.P.A. affairs. This is hardly surprising, however, when so many contacts are through Ministries. The result is that the same stage army of spokesmen and experts appears in Paris with surprising regularity. Another difficulty is the expense involved. Attendance at conferences on the Continent involves travelling and other expenses the results may not justify. But no opportunities for exchanging ideas and information with Continental countries can be neglected.

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Oil Investment Pattern

The United States continues to play the leading part in the development of the free world's oil industry. A recent study made by the petroleum department of the Chase Manhattan Bank in America shows that the share of American enterprise in free foreign crude oil operations in 1955 was 55 per cent. of crude production and 40 per cent. of refinery runs. This is one of the facts which comes out of a study of the investment pattern in the world petroleum industry between 1946 and 1955, a period in which the free world increased its oil consumption two-fold while gross investment in fixed assets went up 2·6 times. During the decade 1946 to 1955 the gross investment in fixed assets per barrel of daily demand went up from 3,469 dols to 4,386 dols. This increase was accounted for mainly by a substantial rise in production costs in the United States and in transportation costs in the rest of the free world.

By the end of December investment in the various aspects of oil refining was as follows: 48 per cent. in production, 17 per cent. in transportation, 20 per cent. in refining and 15 per cent. in marketing. Over the 10 years production took 59 per cent. of the total investment made by the industry in the free world. Thus production continues to absorb most of the capital investment in the oil industry. This would be expected in the United States where the maturity of the industry makes it inevitably a high-cost producer. The rate of capital expenditure in the United States compared with the rest of the free world is, however, slightly more complicated than a simple division into low-cost producing areas and high-cost producing areas might suggest. Thus, the rate of growth of capital expenditure over the last 10 years has been 10·1 per cent. for the free world outside the United States, whose experience is heavily weighted by the Middle East while the rate of growth in the United States has been 8·9 per cent. Over the same period petroleum consumption has increased at the rate of 11·0 per cent. for the free foreign world and 5·8 per cent. for the United States. Thus the rate of increase in capital expenditure in the United States has been higher than the rate of increase in the demand for oil but this has not been true in the rest of the free world. If, however, the trend is followed from year to year over the 10 year period in the rest of the free world, since 1953 there has been a definite tendency for the rate of crude-oil production and crude refinery runs in the free foreign world to increase more rapidly than capital expenditure.

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Nickel in Canada

While the International Nickel Company gave evidence last year of their confidence in the long-term outlook for nickel by starting development of a second large-scale production enterprise in Northern Manitoba, it is possible to detect in the chairman's speech at the annual general meeting last week some anxiety regarding the outlook for the next few years. The outlook for nickel is in fact somewhat paradoxical. The shortage of the metal for civilian use still persists but output will be substantially increased over the next four years.

By 1960 International Nickel expects to increase annual nickel capacity by about 100 million lb. compared with actual output last year of 286 million lb. On the basis of the announced expansion plans of other producers they expect that total free world nickel producing capacity by 1961 will be about 650 million lb. If defence demand remains at about its present level and nickel is not taken for Government stockpiling in that year, the 1956 rate of world civilian consumption would have to increase by more than 75 per cent. over the next five years in order to absorb the potential output. The main difficulty in forward planning, however, is to estimate the trend of military consumption.

These considerations have posed some difficult problems in fixing the price of nickel. During 1956 two increases in price took place and as from December the price of nickel pellets from the Mond refinery at Clydach was raised to £600 per long ton. The chairman stated last week, however, that certain existing and potential uses of nickel may be impeded at this price level.

The company's experience since its foundation 55 years ago provides interesting evidence of the improvement in metallurgical processes. At that time substantially the whole of the output consisted of nickel and copper, the remaining components of the ore being largely lost. The company now produce 14 different elements from their ores and while on the basis of their existing knowledge there are no further elements to be recovered, the future holds promise for the recovery of considerably greater quantities of by-product elements than can be recovered to-day.

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A 550 MW Power Station for Yorkshire

The announcement made last week that the Central Electricity Authority will be applying

later this year to the Minister of Power for consent to erect a power station containing a single 550 MW unit at Thorpe Marsh, near Doncaster, is interesting from more than one point of view. Such a set which, it is believed, will operate under normal steam conditions, will have an output twice that of any generating unit so far planned in this country and will, it is stated, be the largest so far planned in the world. Some doubt may therefore be expressed whether it is wise to put " so many eggs into one basket." It must be remembered, however, that even 550 MW only forms a small proportion of the total generating capacity of the country, all of which is, or will shortly be, interconnected. It is further stated by the Authority, in making this announcement, that this station will be required by the early 1960's primarily to meet the increasing demand for electricity in South Yorkshire, an area which it may be recalled is also intended to supply the increasing needs of non coal producing areas, such as London, over the 275 kV Super Grid.

Coal for the new station at the rate of 10,000 tons a day will be drawn both from the Yorkshire and the northern parts of the Nottinghamshire coalfields and will be delivered by rail over the Gowdall to Braithwell mineral line, which is at present little used and is becoming redundant. A difficult transport problem will therefore be to some extent alleviated. The announcement of this intention to erect such a large coal-fired station will provide some reply to those who have argued that the future of electricity supply in this country will mainly depend on nuclear power. The position, however, is that whereas nuclear power stations are being planned to supply loads which are remote from the coalfields the growing needs of consumers in the areas near the mines can most efficiently be met by what are known as conventional thermal stations equipped with modern plant. So far, progress with this station has been mainly confined to the sinking of trial bores, but the inevitable discussions with land owners and the public bodies concerned will soon begin and it is to be hoped that the start of construction will not be too long delayed.

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Horse-power and Wealth

A review of the standard of living statistics—if living standards can be measured in such terms—shows that the more horse-power per worker the greater a nation's wealth. Mr. Edward C. Stevens, vice-president of the Incorporated Plant Engineers and Managing Director of Skil Engineers Limited, gave some interesting facts in a paper to the I.P.E. read at the recent Factory Equipment Exhibition. Mr. Stevens takes the line that " every conceivable tool lies ready to our hands, we have but to grasp them and use them, and our achievements could surpass our wildest dreams." In this he could be much more correct in his assessment that many eminent politicians and industrial leaders who have in recent years talked in preaching tones about productivity, human effort and quoted endless examples of factories abroad where people work harder than the British.

Mr. Stevens is refreshingly logical and orderly in his treatment of the subject. First he discusses the design of a factory building to make the use of plant easy and productive. Ideal lay-outs must be accommodated and the need is for a minimum of structural interference. The factory of the future, forecasts Mr. Stevens, will be like a dome for " arches are uneconomical when their span exceeds 400 ft. Domes on the other hand have theoretically no limit to their span, because as we increase the size of the dome, the greater weight of structure is carried by the longer perimeter." On lay-out he concentrates on efficient materials handling which he describes as " probably the most important single factor which determines the lay-out of modern machines." Machines, their combinations and amalgamation in a single process, the availability (strangely neglected in many factories) of " a vast array of new materials," the techniques of automatic controls, and a number of other factors are discussed in a challenging manner.

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Cable Makers' Difficulties

The cable industry has had a difficult time over the past year or so. Orders have tended to decline, for the brunt of the capital expenditure cuts in the C.E.A. programme fell on distribution. Competition for what remained has increased and the passing of the Restrictive Trade Practices Act has disturbed a long-established pattern of trading. Most companies have reported lower trading profits, to some extent the result of lower profit margins but mainly to the fall of 40 per cent. in the price of copper between March and December last year.

The annual statement of the directors of Johnson and Phillips Limited comments that " the continuing reduction in the price of copper involved sales of some of our products in a falling price market and thereby caused unavoidable and substantial losses." Sir John Dean, chairman of The Telegraph Construction and Maintenance Company, Limited (TELCON) reported a decline in the profitability of his company's cables division, " despite substantial orders for many types of cable . . . due to the effect of keen prices on profits . . . aggravated by the very marked drop in the price of copper."

Few of the cable companies reporting in the past few weeks have hazarded an optimistic forecast of prospects during the current year. Yet the experience of Aberdare Cables (Holdings) Limited is not untypical of the industry as a whole. Their chairman, Sir John Pascoe, reported that turnover had been well maintained and that at the end of the company's year the orders on hand were larger than twelve months before. The reduction in the orders placed by the Electricity Boards " had the effect of increasing the intensity of competition " although this was partly offset by increased orders from industrial users. Sir John forecast opportunities for increased business at home " when Government restriction on capital investment has been eased." Certainly there would seem to be few good reasons why an industry so intimately tied to the growth in electricity consumption should languish for long during a period of unparalleled expansion.

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Spring-time for Motor Vehicles

The brisk recovery in motor vehicle production in March, with every likelihood of even better figures in April and May, caused the President of the Society of Motor Manufacturers and Traders Limited to chuckle. Mr. F. A. Perkins, addressing the Society's annual meeting, said " The industry is now doing a really remarkable job in maintaining its traditional role of confounding the critics." Exports particularly have shown a fine improvement. Both in February and March they have been higher than in the same months last year, in March by more than 16 per cent. Output on the other hand still lags behind last year's levels though the gap is closing.

Mr. Perkins argued strongly against what he called " the load of repressive taxation " the industry has to bear on the home market. The argument that restrictions and high taxation on home sales are an incentive to export more would certainly not appear to have been valid in 1956 when exports fell sharply. The directors of Vauxhall Motors confirm this in their annual report published last week, saying that people not familiar with the industry's production methods—presumably the civil servants and politicians who produce the restrictions—must find it difficult " to appreciate fully the effects and consequences of a drastic fall in output." The heavy investment in specialised plant, equipment and tooling needed to produce economically produces very high fixed charges and any under-utilisation of the plant causes " the unit costs of production . . . to rise very steeply." Yet there is little doubt that the industry's strenuous efforts to export more now bearing fruit—assisted by a general lowering of import barriers in leading markets—is in part at least spurred on by the restrictions at home.

Speaking as chairman of F. Perkins, Limited, Mr. Frank Perkins remarked that in order to counteract the rising trend in wages and costs of certain materials " we are making a concentrated effort to re-design our products where economies in production are possible, and are continuously investigating new materials and processes". This is the attitude without which no permanent success in the export field is possible.

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Emphasis on Research

Two of the country's industrial giants recently declared their dividends. British Petroleum increased profits by 10 per cent. to £155·5 million and sales by 11 per cent. to 53 million tons of crude oil and refined products. Imperial Chemical Industries' sales also expanded, by £24 million to £435 million, but profits fell by over 6 per cent. In both cases the chairmen, Mr. N. A. Gass and Sir Alexander Fleck, have yet to make their annual reviews and clothe those staggering figures with comments and observations.

A third giant, Unilever Limited, published the annual report of their chairman, Lord Heyworth. This year, the central theme was research—how it is carried on at Unilever's, a statement of principles and a review of techniques and of world developments. Lord Heyworth remarked that in the United States research is three times as expensive as in this country, perhaps one of the explanations for " the oft lamented shortage of scientists in industry," though this shortage exists throughout the world. It is, however, the contrast in the attitude of scientists to industrial research in the United States and Europe to which Lord Heyworth draws attention. He appeals for a less prejudiced attitude on the part of the academic scientist to industrial research, saying that " . . . many industrial projects differ from academic ones only in their aim," one being commercial application and the other knowledge for its own sake. Yet in industrial research, in addition to the acquisition of knowledge, there is satisfaction " in seeing research applied, in influencing social change and in having the means to initiate such a change."

Lord Heyworth stressed the importance of the need for a constant interplay of research and market research. Unilever attach such importance to the latter that they spend on it each year " an amount no less than half " that of their annual expenditure " on scientific research and development throughout the world." Market research is essential for throwing up ideas for the scientists to work on. It establishes and defines a need, and helps to select the more worthwhile of the projects for new products. Lord Heyworth's statement makes an important contribution to modern thought on industrial research, how it functions and the part it plays in industry.

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Industry's Tranquilisers

Few companies like to be entirely dependent on one industry, particularly if that industry tends to be unstable, and some of the larger firms have lessened it by entering new fields. But in their case—Hawkers are a good example—it has meant adding a number of companies to the group, or building new factories. The average company

which diversifies is not like this. To them it means adding another product to a range often already very wide and uneconomical to produce.

In this context it is encouraging to find a medium size concern, H. Brammer and Company, Limited, who specialise in belting for standard equipment use, "conscious of the constant need to increase the volume of sales and to find new markets for the company's products." The recession in motor vehicles and the current fall in orders for machine tools has not been the signal for an immediate new product chase, as is so often the case.

Many companies acquire new products through associations with foreign companies, as in the case of Acrow (Engineers) Limited, who recently concluded an agreement with the German Demag group. This arrangement, they say, "will considerably widen Acrow's scope in the growing field of mechanical handling." But almost every annual statement made by the chairman of an engineering company contains the gist of this extract from the speech of Mr. E. N. Hall, chairman of Hall Engineering Industries: "There are indications that in 1957 profit margins will be lower due to increasing costs and more intensive competition, but I am of the opinion that the steps taken to broaden and expand the scope of the company's activities, should stand it in good stead." It could do precisely the reverse, unless carefully planned and co-ordinated.

Letters to the Editor

BOOMING CARAVANS

SIR, In your issue of April 26 (page 536), under the above heading, you quote the 1956 production of British caravans as being more than 14,300, and worth nearly £6½ million. It should be pointed out that this is the total production by those manufacturers who are members of the National Caravan Council. The Council comprises the great majority of the well-known manufacturers, but there are some big firms outside it, and although no exact statistics are available, I am confident, from the information reaching this journal, that the 1956 output for the whole industry exceeded 25,000 caravans.

Yours faithfully,
W. M. WHITEMAN,
Editor.

Caravan and Trailer Trades Journal,
Link House,
Store-street,
London, W.C.1.
May 2, 1957.

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TEMPERATURES IN BRAKE DRUMS

SIR, I thank Mr. B. Brian Hundy for his further letter (ENGINEERING, April 26, page 516) and, in particular, for expanding his earlier statement on the development of hair-line cracks.* Inasmuch as we both regard the root cause as lying in the high compressive stresses accompanying the steep temperature gradients during braking, our ideas on this point are not as much at variance as at first appeared.

On his later comment, however, I must suggest that the acceptance of even a 3 to 4 in. rim thickness as being in itself sufficient justification for using the semi-infinite slab formula, instead of the full theory, is hardly warranted. Particulars of Mr. Hundy's standard test conditions are not given and may, in fact, be such as to justify the use of the simplified theory but, where experiments are designed to produce extremes of total energy dissipation in conjunction with extended stopping times, great caution must be exercised in applying the simplified analysis.

On the matter of local temperature irregularities, for which my theory certainly makes no allowance, further reference might be made to the work of Parker and Marshall, who, for non-metallic blocks, showed that spectacular reductions in peak temperatures could be achieved by suitable block design.† In particular, the shortening of a railway brake block to one-quarter of the standard length caused a fall in maximum local temperature from over 800 deg. C. to below 400 deg. C. and "completely inhibited heat-spot formation." They associated this smoothing out of the temperature irregularities with an observed improvement in transverse distribution of contact and commented on the constancy of effective contact area as between the standard and shortened blocks.

This view, I feel, reinforces my own opinion on the unimportance, within broad limits, of the effective contact area of the block and makes it difficult for me to agree with Mr. Hundy in his continued belief in a correlation between low contact area and high peak temperature. Nor do the Parker and Marshall experiments encourage one to accept the inevitability of contact maldistributions serious enough to cause the very high local temperatures mentioned by Mr. Hundy. Rather do they suggest that, unless precluded by the standardisation of existing design dimensions, a great deal can be done to remove these maldistributions, thereby minimising the interface temperatures and, of course, bringing the problem more closely into line with that envisaged in my theory.

Reverting to the racing-car problem for which the analysis was designed, the drum is clearly free from adverse effects similar to those due to the spoked structure of a railway wheel and reported by Parker and Marshall. Eccentricity effects are also likely to be less, with the wheel's smaller diameter; and transverse asymmetry of contact pressure, due to the bevel in the railway tyre and block will be entirely absent in the cylindrical drum.

In conclusion, therefore, I feel that my theory not only provides a rational picture of the temperature patterns occurring, but that, with a properly designed composition lining, well run-in on a cast-iron drum, the departures from the assumed uniform spread of heat over the drum surface will not be so great as to cause really serious errors in the numerical values.

Yours faithfully,
F. K. BANNISTER,
Professor of Thermodynamics.
The University of Birmingham,
Edgbaston,
Birmingham, 15.
May 13, 1957.

* The original article, entitled "Transient Temperatures in Racing-Car Brake Drums," appeared in ENGINEERING, March 8, page 304; and previous Letters to the Editor in our issues of March 29, page 388; April 19, page 485; and April 26, page 516.

† R. C. Parker and P. R. Marshall, "The Treatment of Temperatures of Sliding Surfaces, with Particular Reference to Railway Brakes." *Proc. I.Mech.E.*, vol. 158, page 209 (1948).

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TRADE PUBLICATIONS

SIR, Our College library is now functioning in the new building at Gosta Green and, as part of the information service it provides, we are developing our collection of manufacturers' catalogues.

These are being indexed and organised for use by all departments of the College, as well as by outside inquirers, and we should particularly welcome the receipt of catalogues relating to chemical, civil, electrical, mechanical and production engineering.

Yours faithfully,
E. H. C. DRIVER,
Librarian.
College of Technology,
Gosta Green,
Birmingham, 4.
May 1, 1957.

LIVING IN

SIR, Your splendid leading article on the need for proper residential accommodation for students of all ages, and not merely for undergraduates, is one that I hope will find a munificent response. In Cambridge, where even now almost 10 per cent. of all engineers in this country graduate, the governing bodies of several colleges are urgently concerned with the problems which you discuss.

My own College is anxious to build for precisely those objects which your leading article has in mind: partly to increase the accommodation for undergraduates, at this time of urgent pressure upon entry, partly to provide adequate accommodation for post-graduate men who too often are left out in the cold. The colleges of Oxford and Cambridge represent almost 700 years of private benefaction; if any individual or firm is willing to help us, we are ready to discuss our needs and aims at any time. The benefaction will be emphatically well spent.

Yours faithfully,
D. B. WELBOURN, M.I.Mech.E., A.M.I.E.E.,
Dean.
Selwyn College,
Cambridge.
May 11, 1957.

Editors' note: In referring to a recent donation to a London college, we stated that "Vickers have recently given the Imperial College £1 million to build hostels". We regret the error. In fact, Vickers Limited are giving £150,000 for building a new hall of residence, to be known as Weeks Hall.

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NOTATION IN STRESS ANALYSIS

SIR, In my opinion, there is too much diversity between the various English writers on the subject of stress analysis, whether under the title "strength of materials" (a well-established misnomer) or the "theory of structures."

I should like to suggest that present and future authors, including anyone who may be revising his book for a new edition, should adopt the notation recommended in B.S.1991 (Part I) 1954, with the following qualifications:

Tension or thrust in a structural member: P
Energy or work: U
Stress of any kind: σ } with suffices as
Strain of any kind: e } required for clarity
Suffices,
- direct stress or strain: xx; yy, etc.
- shear stress or strain: xy, yz, $r\theta$, $\theta\phi$, etc.
- (one suffix or two, the same being used to indicate direct stress or strain and two different for the shear condition)

Poisson's ratio: ν
Beams,
- bending moment: M
- loads: W, w
- shearing force: F
- deflection (general): y; (particular): δ
- radius of curvature: ρ
- distance from neutral axis: y, $y_{max.}$
- second moment of area, *not* moment of inertia: $\int y^2 d\,A$, etc., or $I = Ak^2$, where k is the radius of gyration about the axis in question.

Shafts,
- second moment of area about torsion axis: I_0
- twist per unit of length: τ
- twist on whole length: θ.

It would be very helpful to authors to have the opinions of professors and others at the universities and technical colleges, and from persons engaged in industrial design.

Yours faithfully,
JOHN CASE.
Charlbury,
Oxford.
May 6, 1957.

ENGINEERING FIRMS IN THE FREE TRADE AREA

1—ASEA OF SWEDEN

Scandinavia is a possible member of the Free Trade Area. If it comes in it will bring with it one of the most enterprising groups in the electrical engineering industry. How does this group look on the eve of the birth of the Free Trade Area? As with Brown-Boveri in Switzerland, Sweden's natural water-power resources contributed a good deal to the raison d'etre *and early success of Asea (Allmänna Svenska Elektriska A/B), which was founded in* 1883 *when electrical engineering was still in its extreme youth. The company has, however, remained in the forefront of technical development and the first commercial atomic pile in Sweden (for district heating only, not power generation) will be close to the company's main works at Västerås.*

In order to understand something of the Asea organisation it is necessary to remember that Sweden is a country of dispersed population, resulting from the nature of the terrain, and has had a shortage of labour for a long time. Consequently, companies which wish to expand often have to locate subsidiary works where pockets of labour are available, regardless of managerial difficulties and costs of travelling and transport. One of Asea's more recent branch works is at Robertsfors, north of Umea and about six miles from a railway. It is a small town of 3,000 inhabitants where labour had been released through the closure of a paper factory, so Asea established a plant there for the manufacture of glasswool which is spun and woven into cloth and tapes.

The company's headquarters are at Västerås where there are seven separate factories and the head office, altogether employing just under 8,000 persons (including office staff). The second most important works is at Ludvika where the production of transformers is concentrated; but in addition to these two places there are about 22 other subsidiary or associated factories, ten of which employ over 500 persons. Such, then, is the scattered nature of an enterprise whose activities range from sheet steel (for transformer cores, etc.) to relays.

PROFITS, OUTPUT AND CAPITAL

The company's annual reports contain unusually full particulars, and before proceeding to a description of its activities three general points are worth making. The first is the relatively high gross operating profit (before tax) on sales, namely about 10 per cent. in 1954, falling, however, to about 7·6 per cent. in 1955. There is a significant difference in this respect between the "modern" industries, whose specialised growth in the countries of high wages and high standards of living is likely to be promoted by the European Common Market, and the older industries whose lower profitability must tend to keep wages down and which are therefore likely to contract in the high-wages countries and to expand in those, like Italy, where there is surplus labour and where wages tend to be lower than in the rest of Europe. Such expansion may even take place partly by transfer of capacity from older countries of production which can no longer compete for labour with, say, electrical engineering, to younger ones. This trend is likely to make itself felt in spite of the provisions in the Common Market treaty for equalising wage rates and social benefits, because the pressure of competition is likely to make itself felt more quickly than are Government regulations.

The second point is the relatively high gross output per person employed—Sw. Kr. 34,000 per head in 1955 (including office workers, who must be included in view of the importance and high cost of, say, drawing office staff and technical sales and after-sales service organisations). This figure is equivalent to about £2,300. The corresponding figure for the United Kingdom taken from the 1951 Census of Production (Electrical Engineering: General, including all workers) was about £1,250, and the difference is striking even allowing for the four-year difference in the statistics.

The third point is the very heavy capital investment necessary in order to bring about points one and two above. This investment is difficult to express in reliable terms because of the difficulty of ascertaining exactly what the company's policy has been in writing-off its fixed assets, which stood in its 1955 balance sheet at Sw. Kr. 449 million or about Sw. Kr. 15,000 per person employed (including office workers). The high expenditure on buildings accounts for a very big part of this investment and, whatever the policy regarding writing-off, outlay has varied between about Sw. Kr. 20 million and 40 million a year (£1·4 and £2·8 million) for a good many years. A whole town block in Västerås is at present being demolished to make way for a new Asea office block and one by one the old dark-red wooden houses are disappearing to make way for the factory whose onion-topped brick and copper tower dominates the town as a symbol of the influence which the company has on its economic life.

PRODUCT RANGE

Asea have been pioneers in long-distance transmission of major quantities of power at very high voltages, partly because a high proportion of the water-power resources of the country lie in the North. The first part of the Swedish 220 kV system was brought into service as early as 1936. More recently, the company supplied the 105,000 kVA generators for the Harsprånget power station and pioneered the development of the 380 kV transmission system in 1952, at the time the highest-voltage system in the world. It was almost entirely operated with Asea equipment. These developments in generation and transmission were accompanied by production of the very large transformers and air-blast circuit breakers required and by other related equipment such as isolators, protective relays, automatic regulators, remote control equipment, surge protection, power capacitors, etc. The company has also done much direct-current transmission work including, in 1954, the first high-voltage transmission system from the Swedish mainland to the island of Gotland.

Asea are large makers of electric motors and have carried out the electrification of many important industrial processes, especially those in which Sweden is pre-eminent, such as paper machines (geared motors mounted directly on the driven shaft, with the advantages of perfect alignment, simplicity of erection and reduced space requirements), printing presses (commutator motors), sugar centrifuges, spinning frames (3-phase commutator motors), rolling mills (geared d.c. motors) and for similar applications.

In the field of electric furnaces, they were early developers of large high-frequency melting furnaces. They also invented a system of automatic electro-hydraulic electrode regulation and induction stirring of the melt, now used in furnaces of up to 150 tons capacity throughout Europe and in the United States.

Electric trains now handle nearly 90 per cent. of the traffic on Swedish lines, and nearly all the electrical equipment, both for rolling stock and power supply, has been made by Asea. Characteristic of Stockholm at the present time are the numerous enormous holes in the ground surmounted by temporary wooden bridges while the underground railway is being built—a considerable feat of civil engineering in view of the fact that most of the city is built on solid rock surrounded by lakes and waterways. Much of the electrical equipment is being supplied by Asea.

Sweden is, of course, an important shipbuilding and major ship-owning country, and Asea make Diesel-electric and turbo-electric propulsion equipment, electrical slip-couplings for Diesel engines, auxiliary power equipment, steering machinery and a variety of deck cranes, windlasses and winches. They also make harbour cranes, industrial and power-station overhead cranes, all kinds of hoists, including mine hoists (which are supplied to the major mining countries such as the United States, Canada, South Africa and others).

The company also makes a variety of other conveying and handling equipment.

GROUP SUBSIDIARIES

The activities described above are mainly those of "Central Asea." It is not possible to mention those of more than a few of the subsidiary and associated companies comprising the group. Three of them in effect provide additional capacity for products made by Central Asea, namely Elektromekano of Hälsingborg (electrical machines, transformers and switchgear), Elektroscandia (metal-clad apparatus) and Graham Brothers (lifts). Liljeholmens Kabelfabrik at Stockholm are one of the three main makers of electric wires and cables in Sweden (the others being Max Sieverts Fabriks A/B, a subsidiary of L. M. Ericsson, at Sundbyberg near the Stockholm airport, and Ericssons themselves at Alvsjö). Asea also own 50 per cent. of the capital of a smaller cable factory at Malmö, Bjurhagens Fabriker A/B. Surahammars Bruks A/B are a steel works making sheet steel (both in carbon steel and alloy steel for electromagnetic and other purposes), wheel tyres and axles for railways, steel castings, sintered products, permanent magnets, etc. The core sheet made at this works is claimed to be of specially high quality.

Svenska Turbinfabriks A/B Ljungström (STAL) have delivered turbines to more than 40 countries. This company also makes gas-turbines, refrigerating plant, air and gas compressors, vacuum coolers, etc.

A/B Elektro-Helios, of Stockholm and Alingsås, make electric cookers, baking ovens, etc., and, in particular, equipment for large kitchens for schools, hotels, etc. A/B Svenska Fläktfabriken, of Stockholm and Jönköping, make electrical

TABLE I SWEDEN: EXPORTS OF HEAVY ELECTRICAL MACHINERY

	1951		1952		1953		1954		1955	
	Metric tons	Sw. Kr. 000	Metric tons	Sw. Kr. 000	Metric tons	Sw. Kr. 000	Metric tons	Sw. Kr. 000	Metric tons	Sw. Kr 000
Generators, motors:										
100 to 500 kg.	1,336	7,843	1,219	9,112	764	5,001	882	4,978	930	5,465
500 to 3,000 kg.	1,611	9,906	1,882	14,846	976	7,965	1,061	7,763	1,088	7,262
Over 3,000 kg.	1,928	12,600	2,212	23,059	1,461	13,028	1,936	17,470	2,214	17,436
Total	4,875	30,349	5,313	47,017	3,201	25,994	3,879	30,211	4,232	30,163
Converters, etc.:										
100 to 500 kg.	165	1,353	220	2,501	124	1,623	164	1,682	201	1,525
500 to 3,000 kg.	504	2,925	353	2,795	175	2,321	328	2,352	473	3,644
Over 3,000 kg.	1,458	7,706	2,714	21,194	1,539	12,326	1,836	14,836	1,678	11,694
Total	2,127	11,984	3,287	26,490	1,838	16,270	2,328	18,870	2,352	16,863

precipitation plant (e.g. for cement works) and pneumatic transport equipment. A/B Asea Svetsmaskiner make resistance and arc welding equipment, welding electrodes, etc. Cebe A/B of Svalöv make a wide range of electric lighting fittings.

Asea has a world-wide sales organisation and has started manufacture in a few overseas countries through subsidiaries. These include A/S Per Kure of Oslo, who make transformers, electric furnaces, electric cookers, etc.; Asea-Hillairet of Paris, who make geared motors, 3-phase commutator motors, capstans, winches, etc.; Asea Electric S.A. (Pty.) Limited of Pretoria, who make transformers, cables and cranes (though suffering like most other South African cable makers from the excessive manufacturing capacity in that country); Asea Electric (Australia) Pty. Limited, of Melbourne, who make motors and transformers, and Asea Electrica S.A. of Sao Paulo, who make transformers. Asea Electric, Limited, London, who make transformers up to the largest sizes, 3-phase commutator motors and hoists, have recently been acquired by Brush subject to the completion of the Brush acquisition by Hawker-Siddeley.

EXPORT FIGURES

Asea probably accounts for a very high proportion of the Swedish exports of heavy electrical machinery. The figures for these are divided only into two main groups: (*a*) generators and motors, and (*b*) converters. These groups are then subdivided according to the weight of the machines.

In 1951 about 52 per cent. of generators and motors and 31 per cent. of converters (based on value) went to Soviet Russia and Poland. In 1952 the percentages for these two countries were 41 per cent. for generators and motors and 63 per cent. for converters. In 1953, when deliveries to Soviet Russia practically ceased, the total of exports dropped by about 40 per cent. (value) but recovered again in 1954. In 1955 there was a slight fall in exports of generators and motors and a rather larger one in exports of converters. Of the European countries, Norway, Denmark and Finland have proved faithful customers over the last 5 years. The Benelux countries and Spain were also steady buyers from Sweden.

Of the overseas countries, South America is important (main customers: Mexico and Brazil). Exports to countries of the British Commonwealth amounted in 1951 and 1952 to 3·5 per cent. of the total value, and rose in 1953 to 20 per cent. (mainly to Australia, New Zealand, Canada and India) and was still 18·5 per cent. in 1954 (mainly to Canada, New Zealand and India). Egypt figured prominently in the heavy range in 1954 and 1955.

It looks very much as if increased competition in export markets combined with a high level of costs at home were beginning to hit Swedish exports in 1955 and this may be a pointer to their competitive position under the European Common Market/Free Trade Area.

The Swedish home market is protected by a minimum tariff of 10 per cent. *ad valorem* plus specific tariffs based on weight according to the scale given in Table II.

TABLE II *Swedish Customs Tariff: Generators, Motors, Converters*

	Sw. Kr.
100 to 500 kg.	28 per 100 kg. net weight
500 to 3,000 kg.	22 per 100 kg. net weight
Over 3,000 kg.	15 per 100 kg. net weight

Duty may not be less than 10 per cent. of the value of the goods and not less than:
Sw. Kr. 38 for 100 to 500 kg.
Sw. Kr. 140 for 500 to 3,000 kg.
Sw. Kr. 660 for more than 3,000 kg

To give some indication of the effect of the specific tariff, the average value of exports of heavy generators and motors in 1955 was Sw. Kr. 820 per 100 kg. and of heavy converters Sw. Kr. 700 per 100 kg. A duty of Sw. Kr. 15 per 100 kg. would thus be much less than the 10 per cent. minimum *ad valorem* duty in both cases. On the other hand, without knowing the average weight per item it is impossible to know whether or not the minimum duty of Sw. Kr. 660 would be payable. It seems likely that the average weight per item in the "over 3,000 kg." class would exceed 4,400 kg. in which case the minimum duty of Sw. Kr. 660 would not operate. For comparative purposes the British import duty is 17½ per cent. *ad valorem*.

GUIDE TO THE FUTURE

In Table III are some key figures from the Asea consolidated balance sheet over the last five or six years. The most significant trend is the very slight increase in the total number of persons employed by the group in Sweden—from 28,625 in 1951 to 30,300 in 1955, an increase of 6 per cent. in five years. Sales on the other hand expanded over the same period from Sw.Kr. 884 mill. to 1,133 mill. (28 per cent.). These figures have to be interpreted with care, first because of the effect of inflation, and second, because there have been changes over the period in the subsidiaries whose figures are included in the group totals (there seem to have been more removals from than additions to the group totals).

It is, of course, very difficult to guess the likely effect of the European Common Market and Free Trade Area proposals on individual companies, but the following are some pointers. Strong and competitive companies are likely to grow stronger, and the weaker ones to find it still more difficult to maintain their position. Specialisation is likely to be promoted. Since many companies, especially in rapidly expanding industries, tend to succumb to the temptation to spread their limited resources of technical manpower, capital, managerial ability and so on over too wide a field, any forced increase in specialisation away from diversification may well lead to an acceleration of the rate of technical advance. Companies with first rate facilities are likely to be in the best position to take advantage of this. A further factor is that companies which are strongly interested in their own home market are likely to fare better than those (like British locomotive and textile machinery manufacturers) who are largely dependent on exports.

On all these counts Asea are likely to do well; the main adverse factors are labour shortage and the future level of costs. Sweden is a high-cost country, not only because of high wages but also, as indicated at the beginning of this article, because of full employment. It is impossible to foresee any very great expansion in the numbers employed in Sweden. There has in fact been only a small rise over the last five years in the numbers employed by Asea, though this has not been due to any shortage of orders. One of the characteristics of the company is the high ratio of "other employees" to "workmen." In 1955 it took two "other employees" to keep three "workmen" employed.

Is there therefore going to be a trend towards decentralisation of production throughout Western Europe by large companies who are technically advanced in their own field?

TABLE III ASEA: SOME FINANCIAL AND OPERATING STATISTICS

—	1951	1952	1953	1954	1955	1956
Group Co.'s sales (million Sw. Kr.)	884	1,022	975	1,045	1,133	1,209
Group Co.'s personnel in Sweden	26,625	28,477	27,186	28,520	30,300	—
Gross profit before tax (million Sw. Kr.)	59·8	73·4	104·9	113·7	108·9	—
Net profit after providing for taxation (Sw. Kr. 000)	20·7	20·8	32·3	37·4	27·3	25·6

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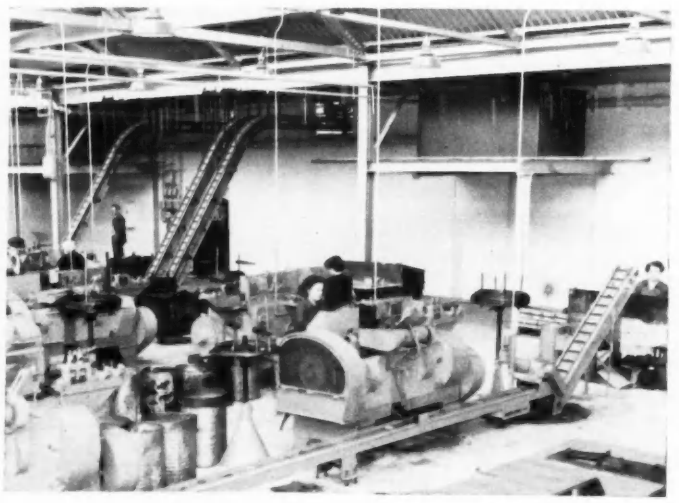
HINGES BY THE MILLION

The manufacture of hinges of all types and sizes is only one of the activities of Thomas Crompton and Sons, Limited, Ashton-in-Makerfield, Lancashire, who produce a large range of builders' ironmongery. Hinge manufacture is, however, a very important branch of the company's business, the products being supplied to many other trades besides that of building, and a new factory has just been opened to accommodate this department.

Situated at Haydock, a few miles from Ashton, the new factory has a floor area of 44,000 sq. ft., and stands on a site of 12½ acres, which allows for future extensions. The buildings are of steel-frame and brick construction, with north lights over the production areas, and are self-contained, with the necessary offices extending along one side. Raw materials are generally received by road, though there is also a rail siding, and finished products are dispatched by road, a common vehicle bay, with an overhead runway and power hoists being provided at the end of the factory. Internal transport is by fork-lift truck.

There are two main production departments, hinge-making and electro-plating, the former, which occupies 28,300 sq. ft., being the larger of the two. Particular attention has been paid to working conditions, and in the plating section the equipment includes not only fume-extraction plant, but also provides for the introduction of sweet-smelling disinfectant vapour at strategic points. Waste liquids from this department are channelled to an underground effluent plant, to be neutralised before being discharged.

The main production section of the factory has three departments—light automatic, heavy automatic, and brass and kitchen cabinet hinges. Equipment in all three is similar. Certain standard machines such as power presses are used, but much of the machinery is of the company's own design and manufacture. These special-purpose machines are built and repaired, and the tools for the Haydock factory are made,



At Thomas Crompton and Sons, Lancashire, hinges are made and assembled by in-line automatic machines and pass by conveyor to packing benches or to an adjacent department for electroplating.

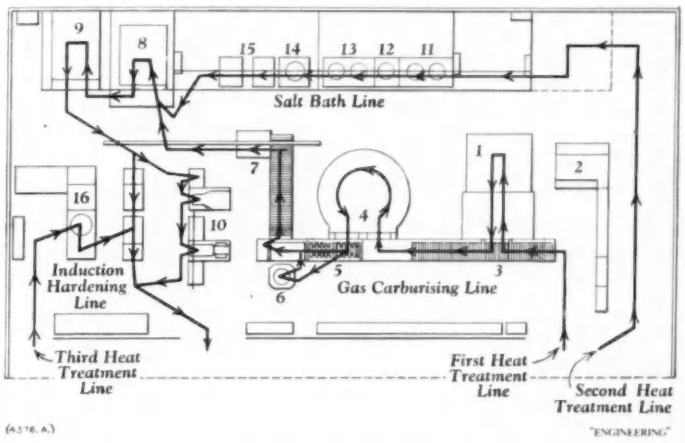
in other works belonging to the company. Fully automatic machines have been under development for some years, and hinges can now be made on production lines which start with blanking and piercing from coiled strip, and end with conveyors which lead either to benches where the finished hinges are packed in boxes, or to the plating shop where a further operation is performed. The latest machines are adjustable to cover a wide range of hinges, and can be re-set easily at the end of a run.

In the automatic lines the blanks are paired as they leave the press and pass immediately to a special-purpose machine which rolls the hinge, broaches the matching faces of the knuckles, and countersinks the screw holes if necessary. Next in the line comes an assembly machine, which cuts the hinge pin from a coil of wire, drives it into the hinge and spins or opens out the ends to prevent it from coming out. This last operation is the equivalent of riveting. Sawdust barrelling is included in the production line so that the finished hinges are clean and free from lubricants used in previous operations. If the hinges are required in natural finish a short length of power conveyor takes them to a bench where they are packed by hand.

PLATING

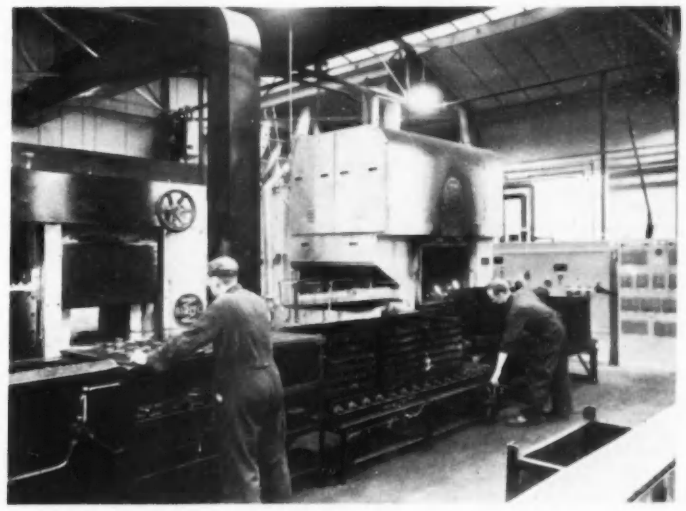
Hinges which are required with a plated finish —and large numbers are so ordered—pass to the plating shop, which adjoins the main production area, but is separated from it by a partition wall. Facilities are provided here for chromium, nickel, brass, copper and zinc plating, and the department deals with products from other works in the organisation as well as those made at Haydock. The equipment is of both the vat and the barrel type, the latter fed automatically under push-button control. Large quantities of hinges for brass plating are transferred straight from three production lines to three receiving hoppers in the plating shop, and from this point they are fed into weigh hoppers which weigh the correct charge for a brass plating barrel. When the operator is ready for a fresh charge, he presses a button, and the weighed charge is released to fall into the barrel which he has placed in position. This equipment was also designed and built by the company.

Ancillary plant in the plating shop includes Roto-Finish machines for de-burring, polishing machines and lacquering equipment. A works laboratory exercises control over plating solutions.



Work-flow diagram showing the three-line heat-treatment shop of the batch-handling type designed for the processing of motor-vehicle transmission gears and the various other components forming part of gearbox assemblies.

1. Gas carburising furnace
2. Control panels
3. Work conveyor
4. Rotary-hearth furnace
5. Quenching tanks
6. Die quench press
7. Degreasing unit
8. Shot-blasting unit
9. Tempering furnace
10. Straightening presses
11. Salt carburising unit
12. Cooling pot
13. Salt hardening unit
14. Quenching tank
15. Washing tanks
16. Induction-heating unit.



Rotary-hearth reheating furnace employed in the first heat-treatment line. Work is charged through the right-hand door and is discharged through the door on the left into oil quenching tanks immediately in front of and under the door.

HEAT TREATMENT OF VEHICLE TRANSMISSION GEARS

Specially-designed heat-treatment equipment capable of processing 1,000 lb. of commercial-vehicle transmission gears every 7 hours has been installed recently by the Automobile Gearbox Division of David Brown Industries, Limited, at Park Works, Huddersfield. Before the new station was laid down, all production carburising was carried out by the pack method in batch-type electric furnaces. The replacement of profile-ground teeth by shaved ones and straight-sided splines by those of involute form, and the correspondingly increased demand for greatly reduced distortion, the preservation of surface finish, freedom from superficial damage and increased fatigue resistance, made it necessary to introduce new methods of heat treatment capable of meeting these more exacting requirements.

The design of the new station gave rise to a number of problems, not the least of which was how best to compress all the units into the available floor space and how best to cater for the wide variety of parts which would flow through in small batch lots. This last factor largely determined the choice of a three-line station, with individual units, of the compact batch-handling type. The various units and their purpose are depicted in the work-flow diagram shown in the line drawing immediately above.

FIRST HEAT-TREATMENT LINE

The first and main heat-treatment line has been planned to take the bulk of the transmission gears which flow in regularly and in suitable batch quantities and weights. For carburising these parts the choice has been a horizontal gas-carburising plant heated by means of radiant tubes. Furnaces of this type are generally constructed to allow for the direct quenching of the work, but since most gearbox gears need individual attention during quenching, the construction has been altered so that the work can be cooled slowly in a gas-tight pit.

The gears to be treated are packed in rectangular containers standing on a roller conveyor of convenient height and the charge is raised to the sill of the furnace on a hydraulic table so that it can be pushed into the vestibule of the furnace. From this point onwards the charging operation is automatic as all the furnace movements are push-button controlled. After closing the outer vestibule door and opening the inner door, two rotating screws draw the box to the rear of the furnace and the operation is repeated for the second box. The heating rate of the furnace is rapid as there is powerful forced circulation through the charge, while special refractory walls between the radiant tubes and the boxes function as reservoirs of heat. Throughout the heating cycle a neutral carrier gas is generated in the inner tubes and this prevents the scaling or decarburisation of the work. During the active carburising stage the atmosphere is enriched with butane gas metered into the furnace.

In order to obtain optimum quality of product, fine-grained steels are exclusively used and the processing temperature, and the active carburising diffusing time ratios, are closely controlled to give the most suitable carbon gradient in the carburised case and the absence of grain-coarsening in the steel core.

Although "normal," or in other words, not high, temperatures are employed, the rapid heating ensures a relatively short carburising cycle and a charge of 1,000 lb. of work can be processed in 7 hours. There is no undue delay in emptying and re-charging the furnace since the completed charge can be transferred, by pressing a push-button, from the furnace and sealed in the cooling chamber without having to open the outer door. In this way there can be no complaints of smoke or radiant heat given off from an exposed charge in the shop.

When the charge has cooled to room temperature, it is transferred by means of a conveyor to the reheating furnace which is of the variable-speed rotary-hearth type seen in the photograph shown above. This unit, produced, as will be seen, by Birlec Limited, Birmingham, is electrically heated and is atmosphere sealed. The provision of a charging sill at the charging level and of oil-quenching tanks set immediately in front of and under the discharging door, eliminates all need for lifting and carrying the hot work. To avoid any possibility of the oil vapour igniting when the discharging door is opened the tanks are made as small as possible and an extracting system has been fitted just above the oil level so that objectionable fumes cannot escape from the top of the tanks into the shop. The furnace doors are operated by pedals, thus leaving the hands free to work the valves controlling the hydraulic tables inside the quenching tanks. No up and down movement of the work is necessary as oil is pumped into the tanks at

a rate of 300 gallons a minute and this provides sufficient agitation.

After the quenching operation the gears are taken along another horizontal conveyor to a degreasing unit, following which they are cleaned by blasting with fine round shot and tempered.

SECOND HEAT-TREATMENT LINE

The second heat-treatment line, which is intended to cater for all the small parts and those which cannot be accommodated economically in the gas-carburising unit, consists of salt-bath furnaces, cooling pits, quenching and washing tanks, all built into a rectangular unit and enclosed by a hood with its own fume extraction system. As the work has to be raised and lowered in each operation, a monorail hoist with a station index serves the whole unit. The work is first loaded into basket-type carriers and is not disturbed until the final washing operation is completed. The sequence of operations is shown in the work-flow diagram and comprises preheating, carburising in a salt-carburising furnace, cooling, hardening, and washing. The work is then shot-blasted and tempered. The temperature of the salt baths are controlled automatically and in this plant a depth of case of 0·040 in. is obtainable with a work charge of 250 lb., in a total cycle of 4½ hours.

THIRD HEAT-TREATMENT LINE

Components other than gears, forming part of gearboxes and requiring some form of local hardening are treated in the third heat-treatment line in which the induction hardening process is employed. The installation consists of a 25 kW valve oscillator set with the energy output leads coupled to a capstan-type work head, an arrangement allowing four permanent hardening fixtures to be used. As the main application of the equipment is the surface hardening of selector rods, a vertical traverse is incorporated in the head and the high-frequency current is controlled by switch contact templates made to suit each design of rod. As is the case with most installations of this type, the treatment proceeds automatically once the controls are set and the starting button is pressed. The ability of the equipment to soften as well as to harden is exploited in the annealing of the hardened keyways and the screwed portions of shafted gears. One important outcome of the adoption of induction hardening for most of the non-gear parts of gearboxes has been that alloy steels could be replaced by the more readily available and less expensive carbon steels without loss of performance in service.

With heat-treatment installations of the type described, development activities are continous and, at the present time, work is going ahead on the design of an automatic programme controller for the gas-carburising unit. This, when installed, will control the furnace atmosphere and the carburising cycles, thus making the carburising operation fully automatic.

By building most of the plant to the firm's own design, special handling equipment has been incorporated at relatively low expense.

INDIVIDUAL SKILL IN MASS PRODUCTION

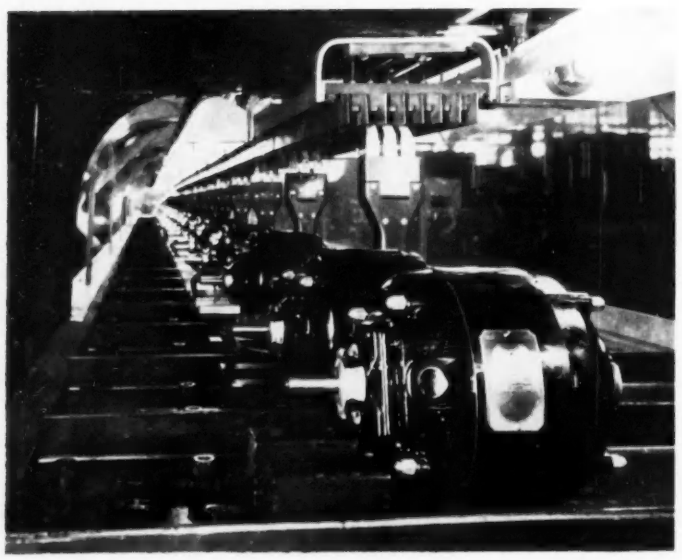
Advantages of Good Labour in a Large Firm

The presence of a high degree of mechanisation does not remove the need for skilled craftsmen. On the contrary, it augments it. For in the tool-room of a factory using a large amount of automatic plant there is a constant demand for skill and ingenuity of the highest order—to produce new mechanisms, accurate dies, etc.

An example of this is to be found at the British Thomson-Houston Company, Limited, Newcastle-under-Lyme, Staffs. The company produce some 9,000 different ratings, types and sizes of fractional-horse-power electric motors. An example of the high degree of mechanisation is provided by the endurance tunnel, shown in the illustration. Finished motors pass on a moving belt through the tunnel. Overhead rails carry current to each motor and a sequence of contacts starts and stops each motor about 55 times in 55 minutes. Should a fault develop on a motor during its passage through the tunnel an audible warning is given in the control room. The simultaneous illumination of a lamp on the panel of the room identifies the faulty motor, allowing it to be removed from the tunnel. Different combinations of overhead rails and contacts allow the whole range of motors to be tested in this manner.

As an example of the value of skilled staff, the machining of a special die for the production of motor end-shield castings might be cited. The motor end-shield is formed at one stroke of the pressure die-casting machine. The die used in the machine must be of high quality and finished to within very fine limits. The company estimate that whereas the die would cost £600 if it were made by an outside firm, its price is reduced to £350 when manufactured by their own staff. However, although this is a concrete manifestation of the value of skilled staff there are other advantages, sometimes more important, that are less easily priced. The chief of these is the gain in flexibility. Noticeable in the Newcastle works is the variety of special machines that have been developed by the staff as the requirement arises. A thread-rolling machine that picks up a rod from one box, rolls a thread on one end, reverses the rod, rolls a thread on the other end, and then places it in another box is a typical example of such a machine.

To ensure a supply of technicians, craftsmen and apprentices, an apprentice training centre has been set up on the site. The course is of five years duration. Semi-skilled staff, such as coil winders, receive their training from the section leader, in the shop.



In the endurance tunnel at B.T.H., Newcastle-under-Lyme, motors are started and stopped 55 times as they move down a conveyor belt. Should a fault develop in one of the motors, an audible warning is sounded in the control room and identifying lights enable the defective motor to be retrieved.

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PLAIN BEARING FAILURES

Four Main Causes

Four main causes for failure of plain bearings are specified by the author of a recent paper.* They are: faulty design, manufacture, assembly or use. Any one is sufficient cause in itself, but they cannot always be entirely separated.

Considerable literature exists on the design of plain bearings, but in spite of this fact design is only a routine matter in simple cases where, for example, the load is constant in magnitude and direction and the sliding speed is no more than about 50 ft. per second. Probably the most common of the heavily-loaded bearings are those used on the crankshafts and connecting rod big ends of internal combustion engines, and the design of these bearings to date has been an evolutionary process based on experience, trial and error. Nevertheless, relatively few bearings fail because of inadequate design, but unsuitable oil grooving is probably the most common design fault.

Millions of plain bearings are made every week in Great Britain, and such is the rigorous control exercised over the metallurgical properties and size limits of the bearings that failures due to faulty manufacture are rare. One of the most difficult things to control is the bond between the white metal and the steel backing of individually-lined bearings. If the bond is faulty the white metal may not be adequately supported, with failure of the bearing as a result.

A variety of failures can result from assembly or fitting faults, some of them very obvious, but still found in practice. With modern thin-walled bearings, for example, cleanliness is important. A small particle of grit or metal trapped between the back of the bearings and the housing into which it is fitted can produce a heavily-loaded spot in the bore of the bearing. Heat produced at this spot is substantially insulated from the housing; this, too, is likely to be the cause of a bearing failure.

Thin-walled bearings rely upon their interference fit in the housing to prevent movement when in operation. If the fit is insufficient, fretting corrosion may occur between the back of the bearing and the bore of the housing. If, on the other hand, the interference fit is excessive, the bearing may be crushed near its joint face.

Bearings failing through misuse can be grouped into those which fail as a result of neglect on the part of the user, and those which come under the influence of some new condition which operates fortuitously. An example of the latter is provided by an actual case of bearing failure in the engine of a commercial vehicle. This engine, like some others of its type, was governed to a pre-determined maximum speed, but it was possible for this speed to be exceeded by running the vehicle downhill in low gear. Investigation showed that on the vehicle in question this over-speeding had happened frequently. High sulphur content in lubricating oil, causing it to become acidic and so cause corrosion of bearings of the copper-lead type was a source of trouble in the past, but this type of failure is now rare, as copper-lead bearings are corrosion inhibited and neutralising additives are included in most modern crankcase oils.

Failures still occur, however, for which no clear explanation can be found and this confirms the view that knowledge of the behaviour of bearings other than those subjected to fairly simple load/time patterns is still scanty.

* "Diagnosis and Analysis of Plain Bearing Failures," by P. P. Love, B.Sc., Wh.Sc. Institution of Engineers and Shipbuilders in Scotland, 30 Elmbank-crescent, Glasgow.

APPLICATIONS OF NICKEL IN INDUSTRY

In the course of his presidential address to the Institute of Metals, delivered in London on April 30, Dr. L. B. Pfeil, O.B.E., F.R.S., a director of the Mond Nickel Company, Limited, and of Henry Wiggin and Company, Limited, made some reference to the applications of nickel in industry. He stated that while pure nickel was used for coins and for other purposes, the metal was essentially an alloying element. Outstanding examples were the austenitic stainless steels generally containing 8 per cent. of nickel and 18 per cent. of chromium and, at the present time, about one-third of the nickel available in the free world was used in their manufacture. This represented the largest consumption of the metal in any single field of application.

Second only to the application in stainless steels was the use of nickel in constructional alloy steels, an application which until recently had been the largest single consumer. In fact, it had been the recognition of the circumstance that the addition of nickel to steel gave a stronger and a tougher product, which, some 60 years ago, had stimulated increased nickel production and, over the years, had been largely responsible for the development of the industry.

For some years, the demand for nickel had exceeded the supply and this had led to the exercising of the greatest possible economy in its use. As a result of extensive research on alloy steels much more was now known regarding the fundamental effects of nickel, both alone and in combination with other alloying elements such as chromium and molybdenum; so much so that binary and ternary alloy steels containing lower amounts of nickel had largely superseded the straight-nickel steels previously employed.

Research had shown that elements present in no more than traces could play a vital part in determining the heat-resisting qualities of an alloy. Thus, less than one part in a thousand of cerium had been found to increase the test life of 80 : 20 nickel-chromium wire for domestic electric heaters by a factor of ten. The realisation of the significance of minor elements in modifying the properties of the nickel-chromium alloys of this type, however, had been destined to prove much more widely applicable, and the successful development of the aircraft jet engine had been closely associated with the development of alloys based on the 80 : 20 nickel-chromium wire alloy for electric fires. Obviously this material would not burn away or oxidise appreciably at high temperatures, but it was not strong enough to resist the high stresses to which jet-engine components were subject, and some means had to be found to make the alloy stiffer at high temperatures without rendering it impossible to fabricate complex components by forging, rolling and other similar means.

The solution had been found by the introduction of additional elements that rendered the alloy " precipitation-hardenable." At the forging temperature the material was single-phase and soft but at the somewhat lower temperature involved in jet-engine service, precipitation of a second phase occurred, giving the desired stiffening effect. Thus had come into existence the Nimonic series of alloys, namely, electric-resistance wire material stiffened by the introduction of titanium and aluminium. The merits of further additions, such as cobalt and molybdenum, had been ascertained and commercial developments had followed.

In heat-resisting alloys there were two types of trace elements—the good and the bad. Among the good, reference had been made to cerium. To this might be added zirconium, calcium, thorium and boron. On the bad side, lead tin and bismuth might be scheduled, with sulphur and selenium. It might be that future research would show that there was a third type of trace element, namely, the inert type, but it was abundantly clear that trace elements, in general, played a vital part in the quality of many metallurgical products.

PLASTICS JOINTINGS FOR POLYTHENE TUBES

Fluid Makes No Contact with Metals

A new range of plastics fittings for effecting " make and break " joints in polythene tubing, without the use of special tools and equipment, has been developed by Mange Plastics Limited, Mange Works, 39-41 Margravine-road, London, W.6, in conjunction with Tube Investments (Group Services) Limited. The initial range of fittings comprises straight couplings, elbows and T's in sizes to fit ½ in., ¾ in. and 1 in. bore tubes in both normal and heavy gauges to B.S.1972; reducers to adapt from one bore size to another; adjusters to allow connection between normal gauge and heavy gauge; and adaptors from polythene to metal pipes suitable for either male or female connections. The olives for straight couplings and body units for T joints, elbows and reducers are made from Zeigler polythene, thus providing a continuous all-polythene internal surface.

The fitting is designed to effect a joint by compressing the ends of the polythene tube, which is soft, upon a slightly more rigid member which is inserted into the belled tube ends. The rigid member consists of an olive moulded from high-density polythene made by the Zeigler low-pressure process to a maximum wall thickness greater than that of the tube, and the compression is effected by a nylon ring and backnut.

The advantages claimed for the new process are as follows: the joint is all-plastics, and only the polythene surfaces come into contact with the fluid carried. It provides excellent chemical resistance, and has a sufficient degree of elasticity to escape damage from freezing-up or from water hammer. The joint can readily be assembled on the site by unskilled labour, can be broken and remade repeatedly, and is small and light in weight. The construction of the olive is such that there is no bore restriction and the flow characteristic is said to be better than that obtained with a galvanised or brass compression fitting. When the joint is tightened, the nylon is under tension but, being elastic, it minimises the amount of plastic flow on the part of the polythene as compared with a metal compression joint. As an extra safeguard the design of the fitting is arranged so that any plastic flow would have the minimum effect.

The joint is effected as follows: the nylon ring and backnut are first slipped over the tube ends, which are then immersed in boiling water for 20 seconds and afterwards, by means of an ordinary plumber's cone, they are belled out to roughly 1½ times the original size. The olive is then inserted between the belled ends and the nylon ring and backnut are screwed together.

★ ★ ★

ROTATING SEALS

For rotating seals intended for use in abrasive services, Crane Packing, Limited, Slough, Buckinghamshire, have developed their range of standard seals to include hard metal opposing faces of the insert type. These have been designed to handle such items as calcium sulphate slurry, suspensions of powdered pumice, rouge, sandy water, etc., with which carbon surfaces would have a very short life. They are also useful for mildly corrosive conditions, such as sea water and all types of boiler feed waters but are not suitable for concentrated acids. The metal used is Coromant, which is the trade name for metals produced by the Sandvik Steelworks Company, Limited, of Sweden. The faces are supplied only in matched pairs. Seals fitted with them must be provided with sufficient coolant, as they generate more heat than carbon seals. They are suitable for service in a temperature range from 0 to 100 deg. C. and a pressure range from 0 to 200 lb. per sq. in. Sizes are available for shafts from ⅜ to 2½ in. in diameter.

★ ★ ★

BRITISH STANDARD FOR GAS WELDING OF ALUMINIUM

Considerable progress in welding techniques has been made since the first publication, in 1943, of British Standard 1126 covering " General Recommendations for the Gas Welding of Wrought Aluminium and Aluminium Alloys." A revision reflecting the bulk of the experience acquired has therefore been published and, in this, details of weld preparation have been specified for the first time. Moreover, the clause on filler rods now includes a table which relates the various grades of parent metal to recommended filler rods. Another new feature is a section devoted to " information required by the welding organisation." This stipulates that drawings, charts and working schedules for use by the welder should contain clear technical details regarding the work. The data to be furnished should include the specification of the parent metal; the location, sizes, lengths and details of all welds; and the treatment to be given after welding.

As inadequate flux removal may cause a weld to corrode, details of satisfactory flux removal have been included as an appendix to the standard. Another appendix contains concise recommendations for working the weld metal satisfactorily.

The publication which contains a number of line drawings has been prepared with the full co-operation of the Aluminium Development Association, and copies may be obtained from the Sales Branch of the British Standards Institution, 2 Park-street, London, W.1, price 3*s*., postage included.

★ ★ ★

BORON TRIBROMIDE AVAILABLE

Case-hardening Catalysts

An announcement recently made by Borax Consolidated Limited, Borax House, Carlisle-place, London, S.W.1, is to the effect that experimental quantities of British-made boron tribromide are now available. Many of the reactions of boron tribromide are similar to those of boron trichloride and there are a number of possible applications in industry. For example, boron tribromide might be employed as a catalyst in the isomerisation of certain paraffin and olefin hydrocarbons or in some polymerisation reactions, for making synthetic rubber and high molecular weight resins. Moreover, boron tribromide might be used to promote the synthesis of silicones and similar compounds. Organoboron compounds are becoming of increasing interest to industry and could easily be made by using this new product which is also an effective brominating agent. Very pure elemental boron has been obtained by the action of hydrogen on boron tribromide, and, in metallurgy, the new product is expected to be of value in case-hardening processes. Boron tribromide is a liquid at room temperature and is available initially, for experimental purposes, in 10 gramme, 25 gramme and 100 gramme ampoules.

THE PULLMETER

Stewarts and Lloyds have developed a very high precision load measuring device, with remote recording, which will retain its accuracy over long periods and under arduous outdoor conditions.

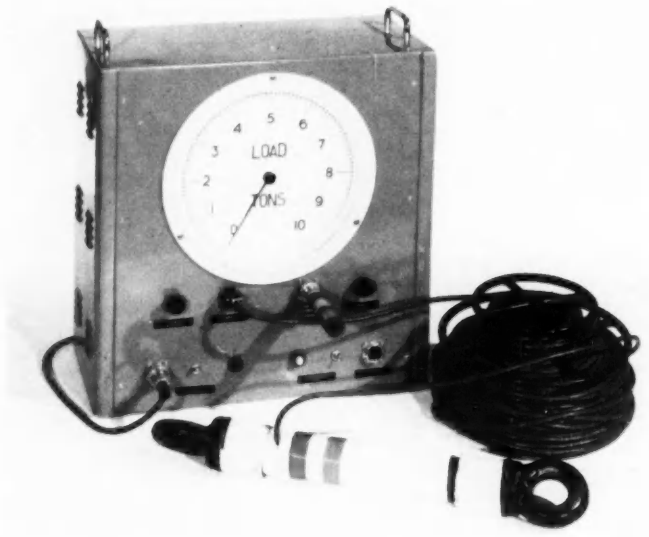
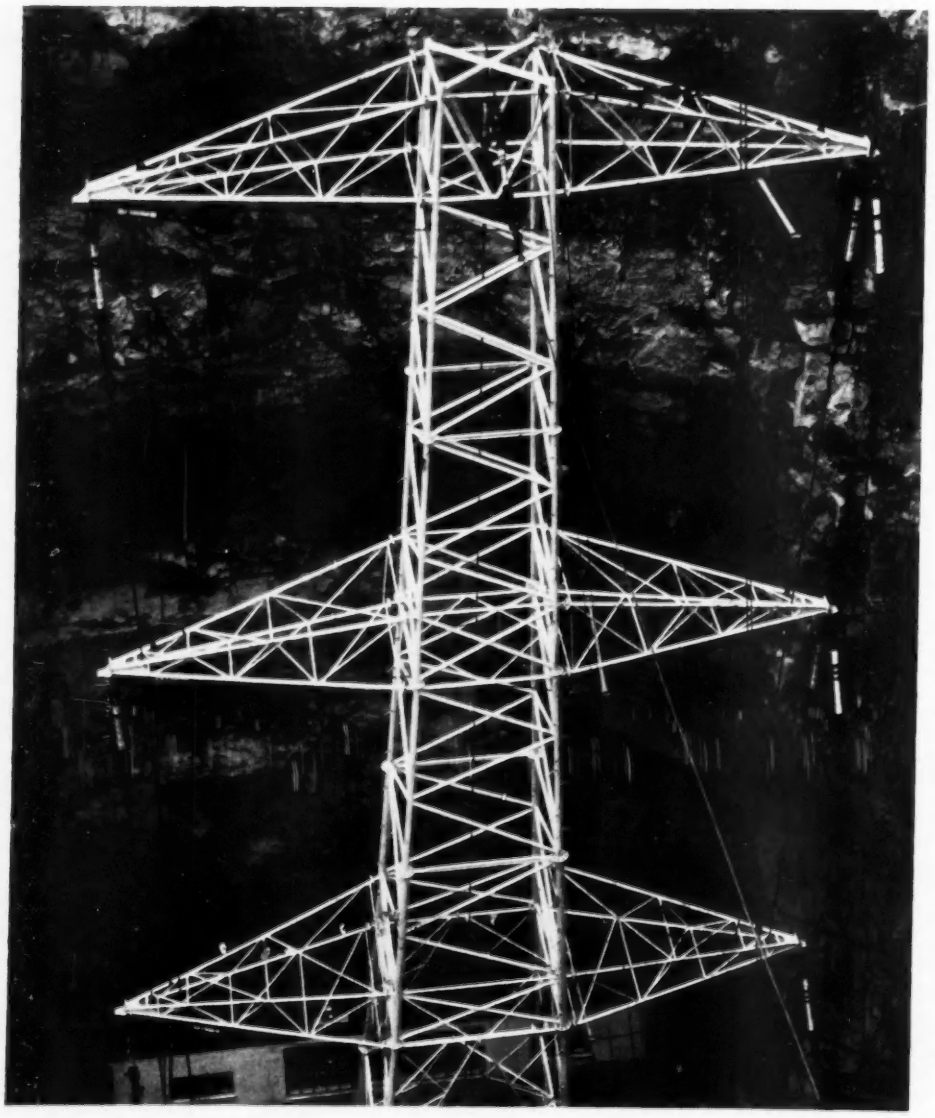


Fig. 1 (left) A " pullmeter " and its associated amplifier-indicator unit. The instrument will permit the remote measurement of loads in cables or, with modification, could be used for determining compressive loads, with a high degree of accuracy.

Fig. 2 (below) The pullmeter has been developed by Stewarts and Lloyds as a load-measuring device for use at the " Monkey Hole," a disused quarry where they test tall structures such as tubular towers. For the test 15 pullmeters, of different sizes, are in use.



SOME time ago, seeking an indicator of very small linear movements for a dilatometer, a differential transformer type of indicator was developed by Stewarts and Lloyds' Department of Research and Technical 'Development until it is now a most reliable and consistent piece of equipment. When later an instrument was required for load measurement in their newly opened structural testing station at Wirksworth, the " Monkey Hole " (a description of the station was given in ENGINEERING for December 7, 1956, page 732) it was suggested that this device could be used to measure the elastic extension of a steel tube and hence the applied load. The resulting instrument has been called a " pullmeter " and is the subject of a patent application. While primarily designed for the measurement of " pull," the same principle can also be adapted to the measurement of " push." When remote indication of load is required, the instrument consists of two parts, the pullmeter itself, which is attached between the structure and the rope by which load is applied, and the amplifier-indicator unit, which is normally placed in some convenient position for observation; at the Monkey Hole, the amplifier-indicator is built into the control console. The pullmeter and load indicator are connected by a light multicore cable and Fig. 1 shows a complete unit. A general view, showing 15 pullmeters of different sizes in use during a test on a prototype 275 kV transmission tower at the Monkey Hole.

The general principles of the pullmeter are shown in Fig. 3. A high-tensile steel tube fitted with suitable end connections for attachment to the rope and structure contains a differential transformer. The coils of the differential transformer are attached to one end of the tube and the core of the transformer to the other. Elastic extension of the steel tube when under load causes the core of the differential transformer to move relative to the windings. The secondary windings of the transformer form two arms of a 50 c.p.s. alternating-current bridge and, with an indicator used as a balance detector, the bridge slidewire can be calibrated in terms of core position. As the extension of the tube, and therefore movement of the core, is proportional to the applied load, it is possible to calibrate the slidewire directly in terms of load. The load can therefore be indicated on a dial, the position of the pointer over the dial being determined by the slidewire adjustment necessary to maintain balance of the bridge.

Pullmeters have been made for maximum working loads of 2, 5, 10 and 30 tons; although the various models differ in size and in certain details, the general construction is similar in each case.

In order to provide sufficient relative movement between the core and the windings of the differential transformer to ensure adequate sensitivity, approximately 0·010 in. elastic extension of the steel tube at its full working load is required. In early models about 0·018 in. extension was used, but further development of the differential transformer resulted in a considerable improvement in sensitivity. If the 0·010 in. extension is to be measured over a gauge length of 12 in., the maximum working strain in the tube is $8{\cdot}3 \times 10^{-4}$, causing a maximum working stress of about 11 tons per sq. in. In addition, for safety reasons, each pullmeter is proof tested to twice the working load and during this test, of course, there should be no permanent elongation in the tube. The tube material, therefore, has to have a proportional limit stress appreciably greater than 22 tons per sq. in.

A suitable composition was found to be the A.P.I. grade J.55 steel containing 0·4 per cent. carbon, 1 per cent. manganese and 0·2 per cent. silicon, which, after quenching and tempering has a proportional limit of 40 tons per sq. in., a tensile strength of 60 tons per sq. in. and an elongation on a length of $4\sqrt{A}$ of 20 per cent.

The required bore of the tube is determined to some extent by the size of the differential transformer and the tube dimensions have been chosen so that a maximum working stress of 11 tons per sq. in. is obtained.

In most cases, the pullmeter tubes were

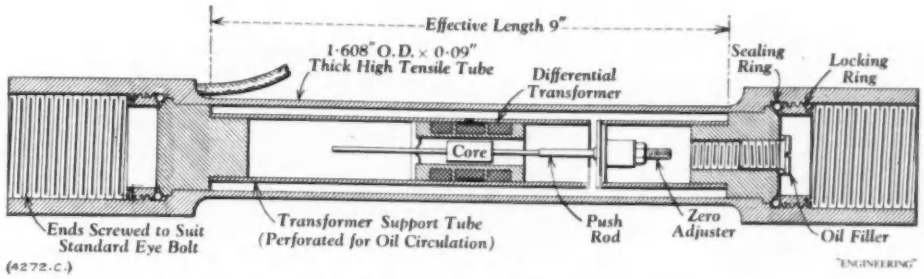


Fig. 3 (left) General assembly drawing of a 5 ton pullmeter. The load to be measured is carried by the tubular housing and the resulting change in length causes a movement of the differential transformer which, in turn, changes the electrical signal sent back to the recording unit. A uniform temperature characteristic is obtained by filling the housing with oil.

machined in one piece from thick tubes after heat treatment, but in early models of the 10 ton units end pieces to take the standard eyebolts were welded on.

The sizes of the effective sections of tubes used were:—

—	Outside diameter, in.	Thickness, in.
2 ton unit	1·00	0·062
5 ton unit	1·58	0·09
10 ton unit	2·25	0·132
30 ton unit	2·55	0·40

SENSITIVE DIFFERENTIAL TRANSFORMER

Details of the construction of a typical differential transformer are illustrated in Fig. 2. The coil former is made of Tufnol and has to be machined to close limits and fitted accurately into its mounting inside a thin tubular cage, one end of which is joined to the pullmeter tube at one end of the gauge length. The transformer core is made from strips of 3 per cent. silicon steel which are inserted into a Tufnol cylinder and bonded with Araldite, after which the cylinder is machined to the required dimensions. The core is mounted on a push rod, one end of which is attached to the pullmeter tube. Elastic strain of the gauge length results, therefore, in relative movement between transformer windings and core. Compensation for thermal expansion is made by using a composite construction in stainless steel and tungsten for the push rod supporting the transformer core.

The cable is bonded into the pullmeter body with Araldite D cement and the exit is made water-proof by means of M.S.4 silicone grease. In order to improve internal thermal stability the units are filled with Kiron oil, the tubular cage carrying the transformer being perforated to allow free circulation of the oil. This oil has excellent electrical properties, a low viscosity and has no hardening effect on the P.V.C. insulation on the wire. In service, the pullmeters are exposed to the weather for considerable periods and it is necessary to provide adequate protection. The outside surface is treated with an etching primer and is then wrapped with two layers of polythene tape, four layers of glass cloth, and finally a further two layers of polythene tape. White tape is used for the outer layers to limit heat absorption from the sun. A colour code system is used for identification of the pullmeters when assembled on a structure.

Fig. 4 (right) The alternating-current bridge and the circuitry between the pullmeter and the amplifier-indicator unit.

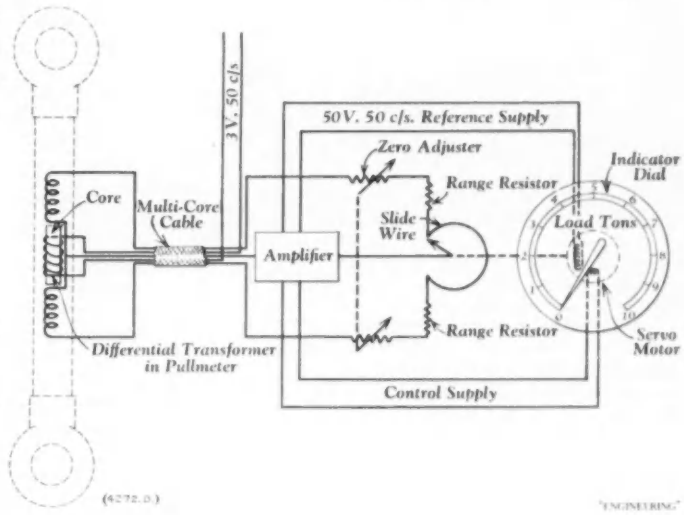
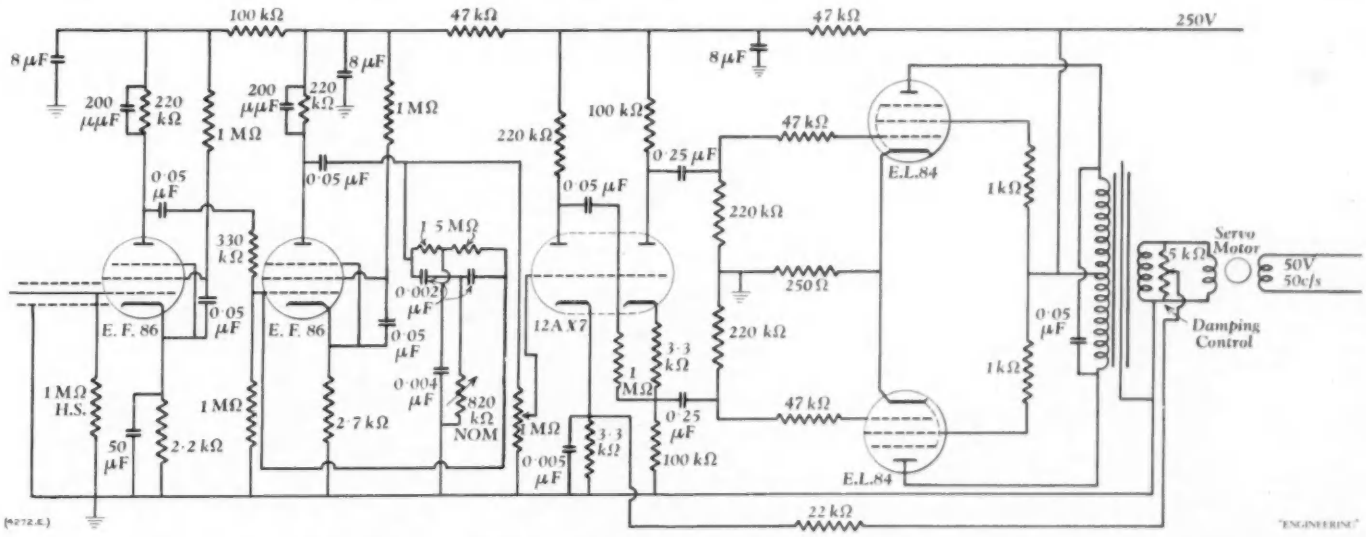


Fig. 5 (below) The 50 c.p.s. servo-amplifier circuit which is used to maintain the bridge in balance by movement of the slidewire contact.



ELECTRICAL CIRCUIT

The circuit of the alternating-current bridge which is contained in the amplifier-indicator unit is shown in Fig. 4. The relative movement between windings and core of the differential transformer which occurs when the steel tube is strained under load results in the bridge becoming unbalanced. The signal arising from this is amplified for the operation of a two-phase servo motor which maintains the bridge in balance by movement of the slidewire contact. The circuit of the amplifier is given in Fig. 5 and a bank of these units is shown in Fig. 6. The slidewire is uniformly wound so that angular movement of the contact is proportional to the load on the pullmeter. As the load indicator pointer is attached to the slidewire contact, angular displacement of this pointer is proportional to the applied load. The indicator dial is 8 in. diameter and carries a scale divided into 100 divisions. Full-scale readings are normally arranged for 2, 5, 10 or 30 tons or convenient values in thousands of pounds. Fig. 7 shows six load indicators mounted in one of the instrument consoles at the Monkey Hole.

All pullmeters and eyebolts are proof tested to twice the maximum working load before being finally calibrated in a 30 ton universal testing machine of certified Grade A accuracy, a master-load indicator being used for adjustment of the resistances which determine the range. It is considered that the inherent accuracy of the pullmeter unit is greater than that of the testing machine, but no more precise means of calibration is conveniently available. The long-term accuracy of a complete unit comprising pullmeter, amplifier and indicator is within ± 1 per cent. of the full-scale reading throughout the range. A deadweight tester of 1, 3 and 5 tons capacity is available at the Monkey Hole for site checking of pullmeters before and after test.

The pullmeters have been found to give consis-

Fig. 6 Six load indicators mounted on a console at the Monkey Hole. (The five upper dials indicate the deflection at different points of the structure, using different sets of gear.) The camera is used to record a corresponding set of dials on a second console opposite.

Fig. 7 Rack of 12 amplifiers and six power units, as installed at the Monkey Hole testing station.

tent and reliable results under the very arduous conditions which occur in an outdoor test on a large structure in adverse weather. They have been found to be very sensitive, giving rapid response and appear to be free from any hysteresis effects.

Pullmeters are equally applicable to other types of load testing, such as loads in towropes both on land and sea, adjustment of rigging ropes, tensions in overhead cables in erection and service, colliery cage loads, loads encountered in ploughing or mole draining, etc. The basic principle of the instrument, namely, the measurement of small displacements or changes in lengths, can of course be made use of in a variety of devices for measurement of movement such as thickness gauges; distortion measurements on structures; weighing machines, continuous and occasional; accelerometers; pressure measurement of both fluid and earth pressures; torque meters; in fact, the list of applications possible for the pullmeter is almost endless.

Institution of Naval Architects Spring Meeting (*continued from page* 587, *May* 10)

SUPERSTRUCTURES AND STRENGTH

At the morning session on March 28, the final day of the Spring Meeting of the Institution of Naval Architects, three papers were presented and were discussed together. They were entitled, "The Interaction between a Ship's Hull and a Long Superstructure," by Dr. J. C. Chapman; "Stresses in Deckhouses and Superstructures," by Dr. A. J. Johnson; and "The Effect of Superstructures on the Longitudinal Strength of Ships," by Dr. J. B. Caldwell.

Dr. Chapman's paper, which, in his absence, was presented by Dr. J. F. C. Conn, described part of an investigation undertaken for the British Shipbuilding Research Association. It was accepted, he said, that the simple bending theory was not applicable to the evaluation of stresses in superstructures, because the curvature of a superstructure would not conform to that of the sides of the hull. It was supposed, from the nature of the problem, that its solution might be reached by applying the principle of relaxation. The investigation was associated with an extensive experimental programme, reported by Dr. Chapman jointly with Mr. S. R. Sparkes, in a paper to the Institution of Engineers and Shipbuilders in Scotland in 1956. A method was developed for finding the deflections and stresses along the length of a ship, taking into account the distortion of the cross-section, the variation of structural properties along the ship, and the different moduli of elasticity of the hull and superstructure.

Dr. Johnson's paper dealt with another portion of the B.S.R.A. programme of research. The purpose was to evolve a reliable method of estimating the contribution of deckhouses to the flexural rigidity of ships, to and in the development of efficient designs and the determination of suitable scantlings, and the accurate prediction of hull critical frequencies. General solutions were obtained in an idealised form of the problem, involving various assumptions and making use of empirical data; it was found that, applying certain approximate corrections, they could be adapted to predict the behaviour of any particular type of deckhouse within the limits of the analysis.

Dr. Caldwell's paper gave a theoretical analysis of the behaviour of ships with superstructures under any distribution of longitudinal bending moments. In calculating the "efficiency" of the superstructure, he showed that it was necessary to take into account various effects not usually considered in strength determinations, such as shear lag in the superstructure, deformation or slip in the connections of the superstructure to the deck, and differential curvature due to the flexibility of the upper deck. He described a practical method for estimating superstructure efficiency and gave numerical results showing how it varied with the ratio of the length of the superstructure to the transverse dimensions, with the flexibility of the upper deck, and with the distribution of the bending moments applied to the ship. He considered only single-deck superstructures, but indicated that the method was also applicable to multi-deck structures. The work had been undertaken at the University of Bristol on behalf of the Aluminium Development Association, and led to the conclusion that the substitution of aluminium alloys for steel would not reduce the efficiency of the superstructure to any significant extent.

FLEXIBILITY

Mr. John Brown, thought that it must be almost unique for the Institution to have three independent papers dealing with the same aspect of the strength of ships presented together.

The methods used took account of the flexural rigidity of the main deck of the hull by means of a term variously referred to as "foundation modulus" or "deflection coefficient" or "deck flexibility." Dr. Johnson and Dr. Caldwell concentrated on the stress at the mid-length of the superstructure, and Dr. Johnson further assumed mathematical similarity of the deflected shapes of the superstructure base and the hull girder main deck at the side; thus his deflection coefficient "C" expressed the relative overall difference between deflection at the plane of the deckhouse sides and the deflection at ship's side. Dr. Chapman's relaxation procedure gave those differences along the whole length of the deckhouse, so he was able to incorporate the effect of rigid bulkhead supports as producing zero relative deflection at their appropriate positions. Dr. Johnson's coefficient "C" permitted the derivation only of the relative difference at midships. The similarity of experimental and calculated results shown in Dr. Chapman's paper demonstrated the probable usefulness of his method, assuming that satisfactory values could be obtained in practice for the foundation modulus in a number of representative cases.

Mr. I. M. Yuille considered that, as ships with long superstructures generally had fairly closely spaced bulkheads, they would tend to make a superstructure bend with the main hull more effectively than the relatively flexible deck beams. Dr. Chapman's paper, by presenting a practical method of calculation, including the effect of bulkheads in the main hull, made an important contribution to the problem. He rightly stated that the connections could be regarded as rigid only if they were so designed; it should not be difficult for the shipbuilders to design rigid connections, having calculated the forces involved. It was in cases where there were fewer than five bulkheads that Dr. Chapman's method of analysis should prove most useful to shipbuilders.

In short superstructures, apparently, shear lag was much more important than in the longer ones. The analyses of Dr. Caldwell and Dr. Johnson applied where there were no bulkheads, which was fortunate, because where the superstructures were short it was more likely that there would be no bulkheads underneath them. Dr. Chapman's analysis took no account of shear lag; but Dr. Johnson's work might be regarded as a first approximation and Dr. Caldwell's as a second approximation. It would be useful to know the length of superstructure below which shear lag became so important that Dr. Chapman's analysis was no

longer sufficiently accurate for design purposes.

Mr. J. M. Murray, M.B.E., thought that Dr. Chapman's hull and superstructure deflections compared well with the deflection coefficients in Dr. Johnson's paper; there was substantial confirmation between the results of the small-scale experiments and the results in the ship.

Both Dr. Caldwell and Dr. Johnson assumed that the deckhouse side was a homogeneous plate, but in practice it was anything but that; most deckhouse sides were pierced by large windows, and recesses for entrances. As a result, the expansion joint might have to be retained; among large passenger liners, many more had expansion joints than not. There was not much trouble with expansion joints. Cracks did occur at the corners of windows and doors where there are expansion joints, but they sometimes occurred there when there were no expansion joints. One method of determining the real efficiency of a deckhouse would be to make model experiments on the lines of those by Dr. Chapman, with the deckhouse side pierced instead of being solid.

MATHEMATICALLY INSOLUBLE

Dr. W. Muckle said that the three papers represented a great advance on anything previously done, but thought that, as the problem was essentially one of discontinuity, mathematically it was insoluble. In the various methods, it was rightly assumed that the stresses at the end of the superstructure were zero, but where the superstructure was attached to the hull, there must be a sudden change of stress from one to the other. None of the methods put forward got over that difficulty. The stress function led to an excellent solution, but difficulty arose over the change of stress. Would the authors care to say what sort of distribution they would get in a long deckhouse or superstructure, assuming that the deck does not flex?

Dr. Johnson neglected the effect of shear lag and suggested that, in the longer houses, it was negligible; but in houses which were (say) 40 per cent. of the length of the ship, the shear lag effect was not negligible. In his own experiments, it was quite marked at about 40 per cent. of the length of the ship. The question arose, whether superstructures should be made fully effective or not. He thought that they should be as effective as possible. The addition of webs or partial bulkheads, as indicated in the papers, would assist, and perhaps pillaring under the deckhouse sides. With aluminium superstructures it was even more important that they should be made fully effective. Mr. Murray mentioned the possibility of carrying out experiments with pierced deckhouse sides. Dr. Muckle recalled that the Aluminum Company of America had made such experiments many years ago; a paper was given in America describing that work, in which both steel and aluminium superstructures were tested with and without openings in the deckhouse sides.

Mr. B. N. Baxter said that Dr. Caldwell had shown how to calculate the efficiency of a superstructure in a quick and relatively simple manner. In dealing with vibration or deflection problems, the amount and distribution of the moment of inertia of the superstructures, particularly at the ends, was of great importance when calculating the frequency using one of the direct methods of calculation.

Dr. J. F. C. Conn expressed surprise at Dr. Chapman's opinion that he would trust the shipyard draughtsman with the relaxation method, but thought that Dr. Johnson's Fig. 22 (showing deflection coefficients) would be a quick and easy help in time of trouble for the ordinary designer. He could not reply for Dr. Chapman, but felt sure that he would be the first to admit that, in a long deckhouse, some account must be taken of shear lag.

Dr. A. J. Johnson said that one assumption common to all three papers was that simple beam theory held good within the main hull girder, but a study of published data would show that there were often considerable discrepancies between the measured and predicted stresses, and that they were liable to occur at positions which were structurally important. Each paper dealt with flexure in the vertical centre-line plane, which was understandable as corresponding to the condition of maximum stress. Horizontal flexure was not referred to in any of the papers. Information on that aspect would be very useful in the investigation of related problems, such as vibration.

BEAM THEORY ERRORS

The papers dealt mainly with the analysis of idealised forms of structures, with possibly too little regard to the implification of the results for design purposes. If, for reasons of stability it was desirable to keep to minimum scantlings in a deckhouse, there might be little alternative to the introduction of expansion joints, though they were often an endless source of trouble. Concentrations of stress at the roots gave rise to local failures which were potentially a danger to the main hull; and there were problems of drainage, and often quite large movements to be absorbed.

It would seem a logical step to suggest practical means of minimising stresses in deckhouses by suitable design techniques. Possible means were to arrange the foundation modulus to ensure that the degree of curvature in the main hull could never be fully developed in the deckhouse, if necessary by some form of flexible connection in way of transverse bulkheads; to interrupt the longitudinal continuity of the deckhouse sides so that they would be incapable of effectively transmitting the shearing stresses to the upper parts of the house; to improve the fashioning of the house ends into the main hull in order to reduce the magnitudes of the local forces in these regions; or, if expansion joints were considered desirable, to avoid high local stresses at the roots. One possibility was to overlap the plates near the hull, those plates being smoothly fashioned into the main strength deck.

Dr. Chapman had demonstrated that the degree of curvature might vary a great deal with distance from amidships towards the house ends, a fact which was not dealt with quantitatively in either of the other papers. Thus arose a condition which, based on Dr. Caldwell's definitions, could produce a superstructure efficiency well in excess of unity at certain positions which were dependent upon the positions of the bulkheads and possibly some distance from amidships. From the point of view of the overall contributions of the deckhouse to the flexural rigidity of the hull, it might be useful if the stress distributions given by Dr. Chapman could be integrated longitudinally to give a mean value of the effectiveness or efficiency.

Professor E. V. Telfer observed that it had been said more than once that the subject would be cleared up more readily if a lot of experiments were made on actual ships; but he did not think that method would be so effective as the use of idealised models. Having obtained by the use of models a clear idea of what could happen, they could go to the ship to have the ideas either confirmed or confuted; it was just as important to confute one's ideas with regard to practice as it was to confirm them. Reference might be made to the paper by G. H. Hoffman, "The effective I of H.M.S. Wolf," given in 1928. It was realised then that it was possible to get very near to those ideas.

Dr. S. Livingston Smith, C.B.E., was gratified by the interest shown in the work by those engaged in the actual problems of practical design, because that was the end point which the B.S.R.A. tried to serve. They had started with simple box girders and built them up, wedding theory to experiment, until they reached the present position. They had been urged to go farther with the model experiments, and at the same time, to experiment on actual ships. The papers had their origin five years before, and it took time to seek the right opportunities to carry out the experiments and make sure they were a success, with the help of the shipowners. After all, it was only by the kindness of the shipowners that such experiments could be made.

Mr. G. M. Boyd concluded that the object of the work described was to find out to what extent the main scantlings of a ship might be reduced if a superstructure were put on it; but care must be taken that, in producing a ship to have a given strength, on paper, conditions were not introduced that would lead to local fractures at unexpected points. During the war, a series of ships was converted for troop carrying. Each had already a superstructure with about three decks in it and it was decided to expand that. In so doing, unexpected stresses were produced in the deckhouse, and it was decided to put in an expansion joint, though, on paper, the concentration at that point was no worse than before the addition was made. Another point was the reverence in which the beam theory was held. He was astonished by the amount of belabouring that had to be applied to experimental results to bring them into agreement with the beam theory. Now that new experimental methods were available, the time had come to disregard the rudimentary things and deal with a ship as a proper structure.

The Chairman, Professor A. M. Robb, recalled an important experiment initiated about 1912-13, when the Allan Line contracted for two considerable ships, the Calgarian and the Alsatian. In the case of the Alsatian, Mr. Foster King had his way in regard to the superstructure; he objected to expansion joints. Throughout her history her performance was remarkable; her superstructure showed much less damage than might have been expected. The Calgarian was built with expansion joints and her life was long enough to enable the shipbuilder concerned to have very fixed ideas on their undesirability.

SHEAR LAG

Dr. Johnson, replying to the discussion, thought that vertical expansion in bulkheads might be more desirable than expansion joints formed by cuts. It should be possible to design a connection capable of taking the small movement that would be required to ensure that a deckhouse moved within prescribed limits. It was true that there always seemed to be residual forces left somewhere; he could conceive of no set of functions which would not give them. He did not see the point of Dr. Muckle's argument, if it was implied that there would be discontinuity of strain at the connection of the house and the hull. (Dr. Muckle: It is stress. You must get that at the end.) He could not conceive that condition. It was interesting to hear that Dr. Muckle considered there were shear lag effects over the whole range; and it was encouraging, because while, in the longer deckhouses, the effect was unimportant, once it was embodied in a theory, it could be extended.

Dr. Caldwell, who also replied, said that theoretically, shear lag was always present, but its effect would be small if the superstructure length was greater than five times its transverse dimension. That was a rough figure which came out of the analyses. In the longer superstructure, the shear lag could be neglected, but in the shorter ones it had an important effect.

Mr. Baxter raised an interesting point in connection with the calculation of the inertia of the superstructure at points other than midships. The results in the paper gave the efficiency at that point, and it could be approximated elsewhere. There seemed to be some difference of opinion as to whether the superstructure should be stressed or not. Sometimes it was of the utmost importance that the superstructure should be stressed as much as possible, lest the stress in the keel should reach an unacceptably high level. If the superstructure did not take part, the scantlings of the hull would have to be increased so that the keel was not overstressed.

The beam theory had come in for considerable comment but for a ship built of many different plates, the only analysis which could deal with it was plate analysis rather than beam analysis. Considerable strides were being made with that type of analysis, but it was not justifiable to condemn the beam theory out of hand.

To be continued

WHAT THE OTHER HALF MAKES

ENGINEERING PRODUCTS FROM THE SOVIET BLOC

Continued from page 569, May 3

The scope and character of engineering in the Soviet group of countries may to some extent be judged from a random survey of their products. We have therefore collected information on engineering equipment made in three of the more industrialised members of the group, and in our issue of May 3 (page 564) we described items from the Soviet Union and Czechoslovakia. The article continues with a section on the products of East Germany (the German Democratic Republic). This article, together with one on the problems of selling to Communist countries (March 15, page 322) and another dealing with their probable import requirements, to be published later, form a series based on details obtained at the recent Leipzig Fair.

3—East Germany

During the present century Germany has built up a vast and complex industry, and part of this tradition has been inherited by the German Democratic Republic. It is therefore not surprising that East German exhibits at the Leipzig Fair were many and various, ranging from optical instruments to earth-moving machinery. Items are described below under the following headings: heavy and industrial equipment, constructional engineering, electrical plant, textile machinery, office equipment, agriculture, machine tools, instruments and optics, transport, and equipment for the consumer industries.

Fig. 18 (below) Spherical or screw shovelling machine made by VEB Schwermaschinenbau, Leipzig. Designed for conveying bulk materials, the machine incorporates a boom, which pivots about a horizontal axis to raise and lower the rotating shovel.

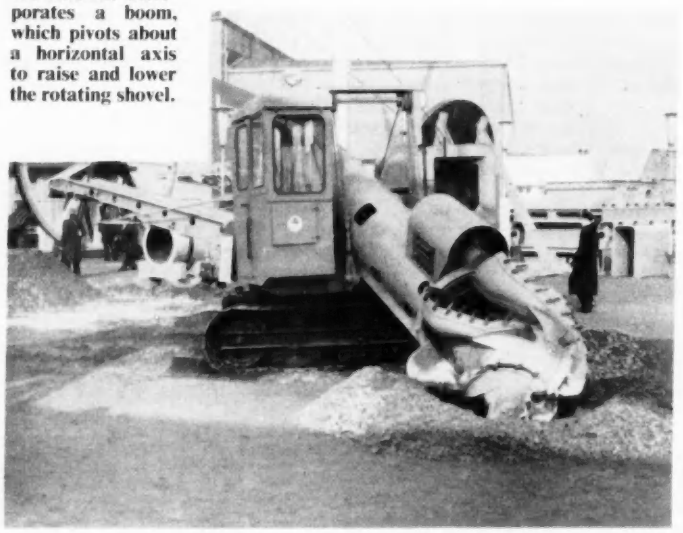
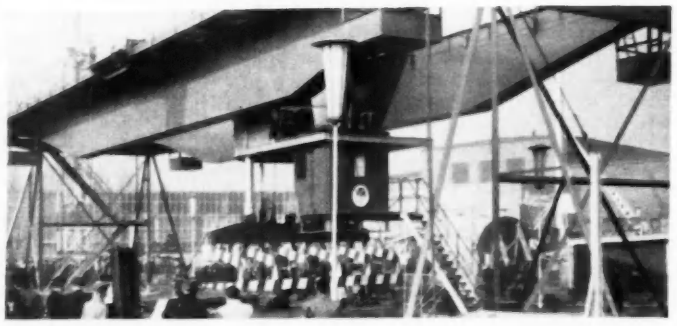


Fig. 19 (right) Gantry claw crane designed to lift a total load of 15 tons, made by VEB Schwermaschinenbau, Leipzig. With a span of 31·5 m., it has a maximum lift of 6·6 m.



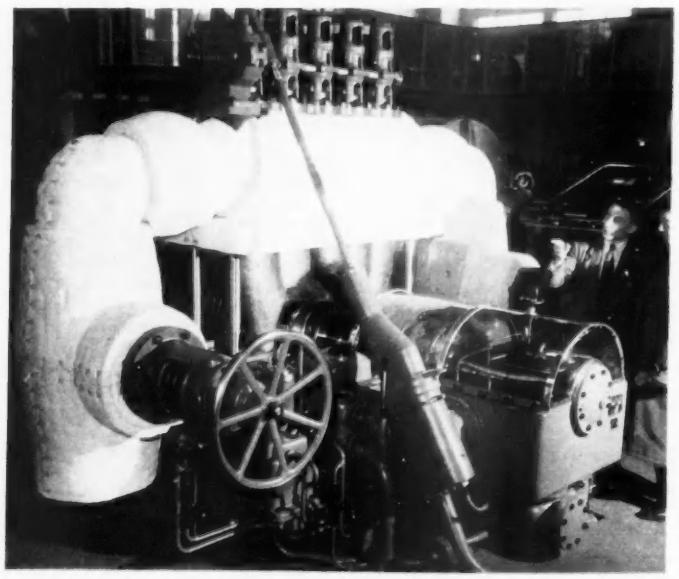


Fig. 20 (right) Commissioned for a brickette factory, the VEB Görlitzer Maschinenbau 12·5 MW backpressure steam turbine is designed to run at 3,000 r.p.m.

Heavy and Industrial Equipment

Mining.—Among various examples of mining plant was shown a coal-cutting machine for use in narrow galleries. The complete unit comprises loading belt, hydraulic advancing machines with auxiliary rams, overhead loaders (capacity 0·2 cub. m.), advancing chain drives, mono-rail conveyors, pillar winches, and shunting crab-gearing machines. A unit undercarriage and components for bucket chain dredgers made by Förderanlagenbau, Köthen, were representative of large-scale open-cast mining.

Handling.—A travelling grab crane for transporting coal and similar materials was exhibited by VEB (Volkseigene Betrieb—People's Own Industry) Kranbau of Köthen. The grab, which is of multi-rope link-operated design, has a capacity of 2 cub. m., and is of lightweight construction using standard components. Portable belt conveyors capable of vertical adjustment are made by VEB Montan of Leipzig. The elevation of the conveyor belts, which range in working length from 10 to 15 m. is effected through a hydraulic cylinder by means of a twin-piston hand pump, and lifting from minimum to maximum height is said to require only 40 seconds. The operating lever may be depressed by a force of 14 kg. The belt, which is of three-layer construction with edge protection, is carried on a cantilever box frame.

Mills and Presses.—Crushers and barrel mills were shown by Schwermaschinenbau Ernst Thälmann of Magdeburg, who also displayed six duo-housings, or two-high mills. A section straightening press made by Schwermaschinenbau Heinrich Rau of Wildau is said to be capable of straightening sections having a moment of resistance of 120 cub. cm. and a cold strength of 80 kg. per sq. mm. (50 tons per sq. in.) at a rate of 92 m. of section per minute. VEB Kema, Keramaschinen, Görlitz, were exhibiting finishing rolls for the fine crushing of lime marl and clay-containing stone. The rolls are of large diameter giving a small wedge angle and hence high performance, while, being designed to rotate at different speeds, they both crush and grind the material as it passes between the rolls.

Foundry Machinery.—A considerable array of foundry apparatus was on display, including core-making and moulding machines. The FRPS 160 is a recently developed jolt-squeeze flask (moulding box)-lifting machine, which operates at ground level and is said to require no special foundations. Other similar machines made by VEB Giesserei und Maschinenbau Ferdinand Kunert, of Schmiedeberg, are the FR20, the FRP10 and the FRS200. The RÖL2 jolt-squeeze flask-lift and the W3 jolt-ram-squeeze turn-over and draw moulding machines were also on view.

Core-making equipment shown included the bench-type FKS2, which is described as a core-shooting machine, the core-blowing machine FKB63 for medium and large cores with two column operation, and the "core-stopping" machine FKST40. Developed by VEB Leipziger Eisen und Stahlwerke, the FKS2 is designed for the preparation of small and medium-size cores up to 2 litres (120 cub. in.) in volume. It is claimed that the principle on which this machine is based leads to reduced wear and hence permits the use of wooden core boxes; the maximum external dimensions of core boxes accommodated by the machine are 280 (11) by 250 (10) by 175 (7) mm. (in.). The rationalisation and mechanisation of foundry operations has been extended to the cleaning and dressing of castings and the discharging of moulding boxes. The following sand-blasting machines were displayed: the PRS900 with caterpillar, fan blower and mechanical charging device; the PDS2500 and PDG1300, each with revolving table and fan blower; and the hand-operated HGD1000. Other exhibits were the PT800 cleansing drum and the SER400 grinder with automatic steplessly variable speed control. Mould discharging and sand preparation equipment was also shown.

Mechanised equipment for pressure and ingot casting were also on view. An improved version of the horizontal pressure casting machine GDH3600 is designed for use with aluminium, magnesium, zinc and copper alloys, and has a closing force of 200 tons. Other similar machines include the automatic pressure casting machine GDH70 for zinc parts up to 40 gm. in

weight, the horizontal chill casting machine GKH20 for light metals, and the vertical chill casting machine GKV2018.

Welding.—For fillet welding the Kjellberg G.m.b.H., of Finsterwalde, have developed a submerged-arc automatic welding machine capable of operating directly on the workpiece without the use of ancillary equipment. It is fitted with magnetic guide wheels to direct its movement in the fillet, and it is claimed that efficient welding is achieved in 90 deg. and U-shaped fillets. Automatic electronic control of current and voltage is provided and the means for re-setting by hand if necessary. The unit, which weighs 50 kg., is known as the " Traktor " and is a development of the Kjellberg universal automatic machine UPU, which is designed to weld butt seams and fillets using either alternating or direct current. The Traktor is lighter than its predecessor and more mobile. The welding head is easily adjustable and travelling and rod-feeding speeds are steplessly variable. Also on display were Kjellberg hollow-cable arc welding units, which have recently been fitted with a special rod-feeding device driven by three-phase motor with cone pulley drive.

Chemical Industry.—Among chemical process equipment exhibited were items for phenol and glycerine production and for the oil and lubricant industries. Plant was shown for processes involving the following materials: mineral oils (rectification and distillation), beet sugar, alcohols, ammonia and other refrigerants, carbonic acid, naptha, oxygen, nitrogen, formaldehyde, paraformaldehyde, hexamethylentetramine, and potassium and sodium compounds. Air distillation plant, fat-decomposing installations, coke ovens, evaporating plant and autoclaves were also displayed.

Building and Construction

Roads.—The mechanisation of road construction was illustrated by the model SBF4 concrete road finisher made by VEB Baumaschinen, of Gutersleben. Designed for the compaction of sub-grade, rough and exposed concrete, the SBF4 is suitable for working widths of 3, 3·6, 3·75 and 4 m. A complementary item is the SBV4 material distributor, which is built to operate at the same widths. The SBF4 requires only one operator and can also be employed for spreading sand and gravel.

Scaffolding.—Safety scaffolding for bricklayers, carpenters, tilers and plumbers working on external walls was shown by Thilo Hoffmann, of Schlotheim, Thüringen. Known as Alpica pull-up protective scaffolding, it makes use of working platforms backed by vertically stretched guard nets, which both prevent the workman from falling and protect him from falling objects. The nets, which are firm but elastic, can be raised by hauling on a cable from the ground. Standard tubular steel frames have been developed by VEB Wutra-Werk, Wurzen, to replace wood scaffolding, which is now in short supply. The sections are joined by standard couplings, swivel couplings, tensile and compressive-shock joints, and also galvanised tubes 48·25 mm. in diameter by 4·25 mm. thick.

Materials.—For sound insulation the firm of Günther Jähne, Löbau, Sachsen, have developed special acoustic slabs, comprising layers of fibreboard, 50 mm. of Piatherm and a lining of matting; the last two being respectively low and high sound absorbers. These " Astik " slabs are made in various combinations to accord with any given acoustic requirements. The lime-wood matting may be of natural wood colour or coloured, and can be impregnated with a fire-resistant preparation. Experiments are being made in East Germany on the use of polyvinyl chloride roofing materials, and prefabricated concrete roofs are becoming standard practice.

Civil Engineering Plant

The VEB Regulus Betonmischerbau, Neustadt (Orla), 13/00·4 concrete mixer and batcher is an example of mechanisation in the building industry. Designed as a single-axle trailer running on pneumatic tyres, the unit is a complete mixing plant, comprising a 55 gal. gravity batch mixer, a batching device with spring balance and four batching belts, and a cement silo with worm drive. Smooth running is achieved by use of elastic drive rollers instead of the conventional gear rim. The maximum output of the plant, which can be fitted with an 800 kg. pull builders' winch or a scraper winch of 300 kg. pull, is 7·5 cub. m. per hour. Other equipment shown at the Fair included the Rapido III slewing tower crane illustrated on page 322 of our issue of March 15, and a small excavator of 0·2 cub. m. capacity. The all-purpose tractor " Maulwurf " is now made with several speed gradations from 1·6 to 15 km. per hour, and as a result of studies on the dust-free transport of binders the Polysius mobile container unit has been developed. Fig. 18 shows a spherical or screw shovelling machine (for conveying bulk materials) made by VEB Schwermaschinenbau, Leipzig; in a previous illustration (March 15, page 324) the same machine was seen with the shovel boom raised.

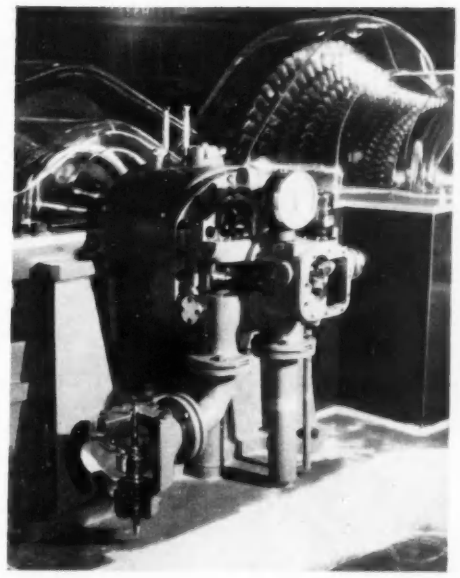


Fig. 21 Hydraulic speed governor for the 5 MW bled-steam condensing turbine generator set made by the VEB Turbinenfabrik, Dresden.

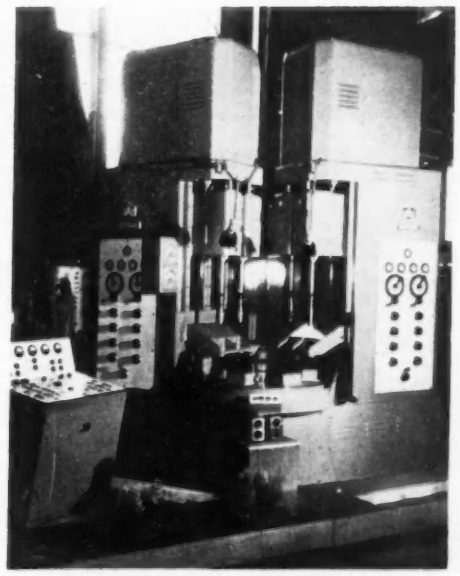


Fig. 22 Four-spindle honing and lapping machine built by VEB Werkzeugmaschinenfabrik, Naumburg. Automatic indexing takes place when air gauges register that a predetermined bore size has been machined.

An overall view of a gantry claw crane, which was also illustrated in our issue of March 15, appears in Fig. 19. With a span of 31·5 m., it is capable of lifting 15 tons through a maximum distance of 6·6 m.

Electrical Machinery and Power Plant

Electrical Apparatus.—Electrical generation plant and switchgear was stated to be flame, explosion and tropical proof. An impulse voltage testing apparatus designed for 1·5 MV was exhibited, which is built to permit the generation of surges rising more steeply and with fewer higher harmonics than was possible with earlier versions.

Turbines.—Steam turbines for power generation and other purposes were shown in considerable numbers. A 25 MW set made by VEB Bergmann-Borsig of Wilhelmsruhr, Berlin, uses steam at 110 kg. per sq. cm. (1,560 lb. per sq. in.) and 485 deg. C. (905 deg. F.). It consumes 281 tons of steam per hour when developing 25 MW at 3,000 r.p.m. The electrical output is rated at 31,250 kVA and 6,300 V. The VEB Görlitzer Maschinenbau, Görlitz, were exhibiting the back-pressure steam turbine illustrated in Fig. 20, which produces 12·5 MW at 3,000 r.p.m. Commissioned for a brickette factory, it uses steam at 36 kg. per sq. cm. (510 lb. per sq. in.) with a back pressure of 5 kg. per sq. cm. (70 lb. per sq. in.). A newly introduced feature of the installation is the use of compensated bearings in the control valves for the coal supply; faults in the bearings arising from temperature variation are thus eliminated. On March 15 (page 324) we published an illustration of the 5 MW turbo-generator set made by the VEB Turbinenfabrik Dresden. The set incorporates a bled-steam condensing turbine, which uses steam at 435 deg. C. (815 deg. F.) and 36 kg. per sq. cm. (510 lb. per sq. in.). The high-pressure turbine runs at 7,500 r.p.m. and the low-pressure turbine at 4,500 r.p.m. The machine is controlled by a recently developed isochronous hydraulic speed governor, which is illustrated in Fig. 21. The governor is driven through gearing from the turbine shaft and by means of an oil-hydraulic system regulates the governing valves and output pistons of four nozzle valves located on top of the nozzle steam chest.

Textile, Paper and Printing Machinery

Textile Machinery.—Of the 48 types of textile machine exhibited, 18 were said to be innovations. Advanced designs shown by the Spinnereimaschinenbau Karl-Marx-Stadt (formerly Chemnitz) included a double-head porcupine drawing frame, an intersecting fly frame, and a ring spinning frame capable of higher spindle speeds than earlier models. The Spinn und Zwirnerei Maschinenbau Karl-Marx-Stadt were showing new flyer and ring twisting frames. The flyer twisting frame incorporated 3,200 enclosed light-metal cap flyers running at between 1,000 and 1,500 r.p.m.; the machine stops automatically when the cover plate is opened. A dividing beam warping machine recently developed by the Schär und Spul Maschinenbau Burgstädt automatically maintains a constant thread speed, thereby avoiding streakiness in finished goods. The machine operates from a 240 bobbin reel. For the overhaul of worn shuttles the Webstuhlbau Grossenhain has produced a loom-shuttle truing machine, while the same company makes an advanced form of high-capacity buckskin loom. Other looms included the automatic TES4200 machine, the automatic colour weaving loom ES4B with low-level dobby, both built by Webstuhlbau Neugersdorf, an automatic loom for weaving coloured woollen fabrics, and an improved Jacquard blanket loom (Webstuhlbau Karl-Marx-Stadt). Also exhibited were tulle machines, stitched-stuff and knitting machines, finishing machines and measuring-doubling winding-on frames.

Paper and Printing Machinery.—A paper making machine of interest was the combination miller and scraper OSH made by the Optima, Fabrik Graphischer Maschinen of Leipzig. It is said to give the accuracy necessary for high-

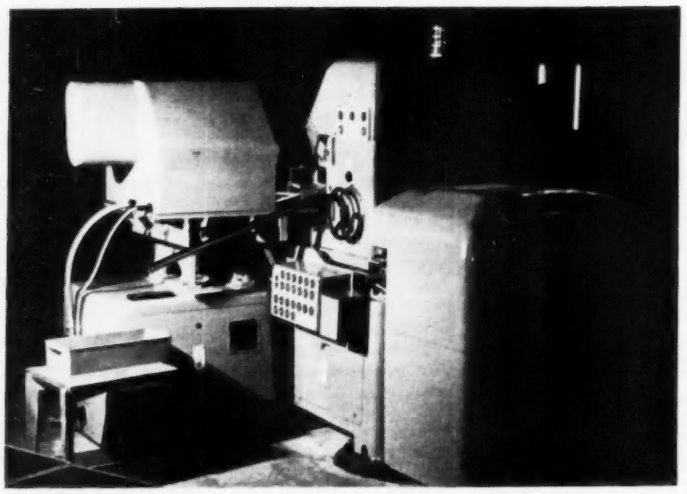


Fig. 23 Centreless grinder made by VEB Werkzeugmaschinen und Vorrichtungsbau Leipzig. Known as the model SASL 125, the machine is stated to be fully automatic.

Fig. 24 Internal and external teeth and single and double helical gears can be cut with the ZStWZ machine made by VEB Zahnschneidemaschinenfabrik Modul Karl-Marx-Stadt.

quality stereotyping, so reducing the non-productive time on surface-printing machines. Colour printing machines were also shown, together with book-making plant. The K14K book press developed by the VEB Buchbindereimaschinenwerk Leipzig has been designed in accordance with advanced ideas of transfer line bookbinding and has an output of 2,000 books per hour.

Office Machinery

Book-keeping.—The book-keeping machines SR 22, SR 42 and SR 54 made by Mercedes Büromaschinenwerke AG., Zella-Mehlis, Thüringen, are now equipped with built-in tape-perforators operating on the 5 channel system of the international teleprinter code. The main field in which perforated tapes are likely to be used will be in the production of punched cards by way of a reversing apparatus and a motor-driven puncher. Baby, standard and electric typewriters were also shown, together with duplicators and calculating machines.

Agricultural Machinery

Ridge Drill.—VEB Landmaschinenbau Bernburg displayed their type 182 automatic ridge drill, which is said to give an increase in performance of 60 per cent. compared with conventional tractor-hitch ridge drills. The machine has been fitted with an automatic setting and lifting device, which can be operated either from the driver's seat or from the running board. The working speed is 7 km. per hour and the transport speed 20 km. per hour. If required, the machine can be fitted with an acreage recorder, depth control, closing devices or closing rings, pressure rollers for grain and beets, interchangeable boxes, and fine or coarse seed wheels.

Planting Machine.—A combination planting machine for hitching to a tractor and suitable for planting seedlings with or without pot-balls and also pre-grown potatoes is made by VEB Bodenbearbeitungsgeräte, Leipzig. It is capable of planting up to 2,500 unpotted or up to 2,000 potted plants per hour and requires a 30 h.p. tractor with hydraulic mechanism.

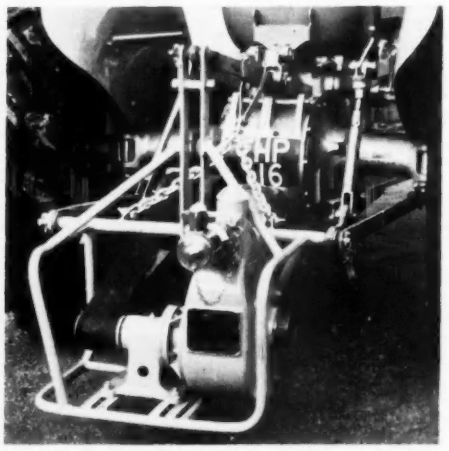
Milker.—For smaller farms with up to 20 head of cattle VEB Elfa, Elsterwerda, have developed the " Piccolo " small mechanical milker. The power and vacuum plant is drawn on skids so that no permanent vacuum line is necessary.

Harvesting.—The universal thresher K117 made by VEB Erntebergungsmaschinen Fortschritt, Neustadt, is suitable for all cereals, fine seeds, clover (with attachment) and maize and incorporates a built-in straw press with divided binding and needle shaft. Ready-for-sale corn sorted into three grades is produced by a pressure and twofold suction effect during cleaning operations. The feeding of the threshing drum is achieved automatically by roller feeders over the full length of the threshing platform, while the steady feed is controlled by an automatic sheaf cutting attachment, with feeding drum. The thresher may be driven by electric motor, Diesel engine or tractor and its output is 29·5 cwt. per hour. Other items shown included a swath-gathering roller for attachment to combine harvesters with 2·1 m. pick-up width (VEB Mähdrescherwerk, Weimar), a potato sorting machine (type KS 2/M) with an hourly output of 128 cwt. (VEB Landmaschinenbau Haldensleben), and a self-cleaning turnip shredding machine (type F 146) with an output of between 68 and 78 cwt. per hour (VEB Landmaschinenbau Barth).

Machine Tools

Woodworking.—VEB Knohoma, Schmölln, exhibited a high-speed band-sawing machine, which is said to be of compact design with fully-enclosed rotating members and an improved blade guide. A three-sided heavy duty moulding planer was shown by VEB Standardmaschinenbau, Markranstädt, and VEB Maschinenbau Lonsdorf displayed a wet-grinding and belt-buffing machine.

Honing and Lapping.—A four-spindle honing and lapping machine built for export to the Soviet Union by the VEB Werkzeugmaschinenfabrik Naumburg is illustrated in Fig. 22. Known as the model SZSM4 by 125 by 320·4 (mm.), it has a maximum honing diameter of 125 mm. (4·9 in.) and a minimum of 50 mm. (2 in.), and a maximum stroke of 320·4 mm. (12·6 in.). Stroke speeds range from 2 metres (6·5 ft.) per minute to 16 metres (52 ft.) per minute and spindle speeds from 20 to 160 r.p.m. The work is carried on a rotating table, and six double-bore air-compressor cylinder blocks can be seen in position. Pneumatic air gauges in the workpiece securing heads measure the work size, and reciprocation of the spindles proceeds until predetermined limits are reached, whereupon indexing automatically takes place. The spindles on the left hone the two bore sizes, while those on the right are for lapping. Coolant is supplied through the spindles.



Mounted on the standard hydraulic lift mechanism and driven from the power take-off, the Watermaster pump can deliver 16,500 gallons of water per hour.

Grinding.—The VEB Werkzeugmaschinen und Vorrichtungsbau Leipzig showed the SASL125 grinding machine illustrated in Fig. 23. It is a centreless grinder with fully automatic operation.

Gear Cutting.—What is described as a new gear-tooth rolling machine was exhibited by the VEB Zahnschneidemaschinenfabrik Modul Karl-Marx-Stadt. It is illustrated in Fig. 24. The machine (type ZStWZ1000 by 10) is capable of cutting internal and external straight teeth and single and double helical gears.

To be continued

* * *

PUMP MOUNTED ON A TRACTOR

Designed for use with Ferguson tractors, the Watermaster mounted pump is being made by James Beresford and Son, Limited, Kitts Green, Birmingham, 33. It is attached to the standard hydraulic lift mechanism of the tractor in the same way as an implement, and is belt driven from a power take-off by a 4 in. wide belt. It will pump water containing up to 25 per cent. of solids, providing the particles are below $\frac{3}{8}$ in. in diameter, and has a maximum output of 16,500 gallons per hour. The maximum head is 200 ft. It is self-priming and has a lift of 28 ft. Standard suction and delivery branches are threaded for 3 in. British Standard pipe thread, and an attachment is available to convert the delivery branch to a $2\frac{1}{2}$ in. instantaneous coupling for use with the standard fire fighting hose. An open-blade non-clog impeller is used. The maximum pressure that can be obtained with the pump is 83 lb. per sq. in. and two $\frac{1}{2}$ in. jets can be used for fire fighting. For pressure washing, smaller bore hose is advisable, 1 in. bore is the size recommended. An automatic self-closing by-pass valve is incorporated within the casing, to facilitate priming and, once this is filled, the pump will operate automatically until the casing is emptied, as for example, a safety measure in frosty weather.

FREE-TURBINE ENGINE FOR HELICOPTERS WITH SHAFT DRIVE

NAPIER GAZELLE CLEARED FOR FLIGHT TRIALS

Ground-running tests of the Gazelle free-turbine engine installed in the prototype of the Westland Wessex naval helicopter have recently commenced, and the engine has also completed a 25 hour " special category " test for flight clearance, well within 18 months of its first test runs. The Gazelle was designed and built by D. Napier and Son, Limited, Acton, London, W.3, primarily as a power unit for helicopters, but it can also be used as a propeller/turbine engine. Gazelles are likely to be used for driving the rotors of the twin-rotor Bristol 192C helicopters that British European Airways hope ultimately to acquire.

The Gazelle now installed in the Wessex helicopter is the N.Ga.1, with an " emergency " static rating of 1,260 s.h.p. The dimensions and performance of the engine are given in Table I below. Later marks of the engine—the N.Ga.2, N.Ga.3, and N.Ga.4, will have emergency static ratings respectively of 1,650 s.h.p., 1,800 s.h.p. and 2,000 s.h.p., and the engine weight will be progressively stepped up, but the engines will otherwise be similar in performance and dimensions to the N.Ga.1.

TABLE I.—*Leading Particulars and Performance of the Gazelle N.Ga.1*

Diameter	33·5 in.
Length	70 in.
Weight	780 lb.

Rating	Emergency static	1-hour static	Maximum continuous static
Shaft horse-power ..	1,260	1,100	920
Compressor r.p.m. ..	20,400	19,800	19,000
Maximum output, shaft r.p.m. ..	3,000	3,000	3,300
Fuel consumption, lb./s.h.p./hr. ..	—	—	0·77
Oil consumption, lb./hr.	—	—	1·0

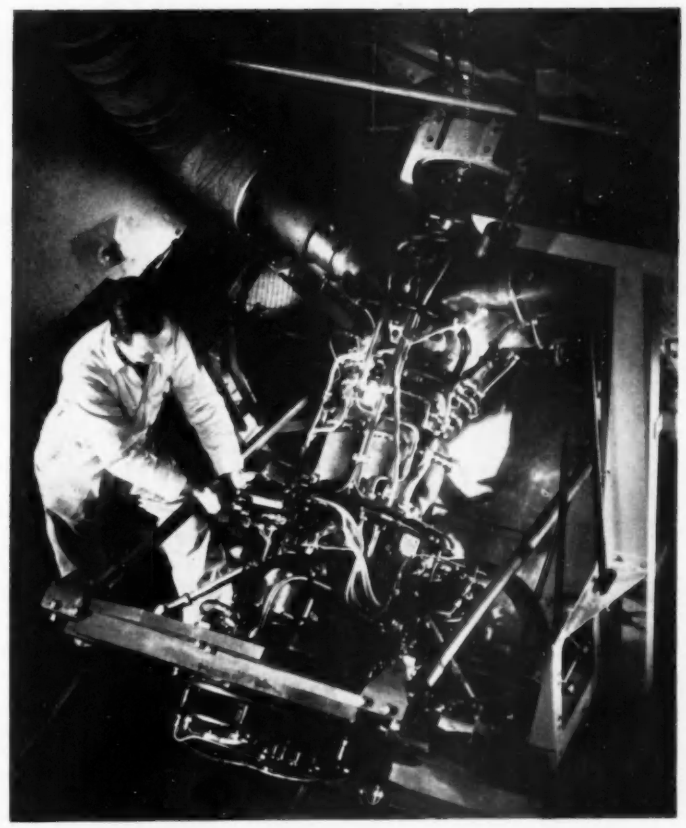
The advantage of the free power-turbine type of engine for helicopter propulsion is that it can maintain a high power output whether the helicopter is in hovering or in forward flight, despite the wide disparity between the rotor speeds in these two conditions. Furthermore, a sudden load does not tend to slow and stall the rotor, nor does a sudden lightening of the load cause over-speeding.

At starting, with the rotor braked, the Gazelle can be run under " no load " conditions—obviating the need for a clutch, and reducing the number and complications of the controls. At low power, optimum rotor speeds can be selected without loss of maximum compressor efficiency and fuel economy; at maximum power, a rotor underspeed of 15 per cent. is permissible. Safeguarding devices built into the control system, in conjunction with safety features incorporated in individual components, provide both primary and secondary lines of defence against the failure of engine components, and ensure that no single failure leads to uncontrolled flight or structural breakdown.

The engine can be mounted at any angle between the vertical and horizontal to suit the installation and can be supplied with either right-hand or left-hand rotation of the output shaft. The control system has been so designed that if one engine in a twin-engined installation fails the power of the other is automatically increased up to a maximum of 30 per cent. in excess of the one-hour rating.

The Gazelle has an 11-stage axial-flow compressor, six combustion chambers, a two-stage reaction turbine driving the compressor, and a single-stage free power turbine coupled to the output shaft through an epicyclic reduction gearbox. Air enters the compressor through a radial intake and is delivered from the compressor to six flame tubes to which fuel is supplied through upstream injection burners. The combustion products pass through the two-stage turbine which drives the compressor, then through a bifurcated exhaust pipe. The power-turbine shaft is situated within the bifurcation of the exhaust pipe and is coupled to an epicyclic reduction gearbox, incorporating a hydraulic torquemeter, from which the final drive is taken. The engine is controlled by a single lever, automatic compensation being provided for changes in flight conditions.

The air intake, which is cast in magnesium alloy, provides a mounting for the engine accessories and houses the variable inlet guide vanes. Protection against icing of the intake is provided by oil-heated jackets, and the inlet guide vanes are anti-iced by passing hot air, bled from the compressor, through them.



The Gazelle gas-turbine, seen here on its testing rig, is designed primarily for helicopter rotor-shaft drives.

The compressor, which has a constant outside diameter, supplies an air flow of approximately 16 lb. per second at a pressure ratio of 6·37 to 1 at the emergency rating. The compressor gives optimum efficiencies which are well removed from surge throughout the entire speed range. At low engine speeds this margin from surge is further increased by the use of the variable-incidence inlet guide vanes, which are controlled by a speed-sensing servo unit.

The compressor blading is of aluminium bronze, a material which combines high fatigue strength with excellent corrosion resistance. All the rotor blades are secured by fir-tree roots to the compressor discs which, from stages two to seven are of aluminium, the remainder being of steel. The compressor casing, of magnesium-zirconium alloy, carries the stator blading, the first three stages of which are shrouded. A roller bearing, situated in the air inlet casing, and a ball bearing within the main support plate, together carry the hollow-steel splined shaft.

The support plate forms the structural foundation of the engine, having the compressor casing bolted to its lower face and the outer casing of the combustion system secured to its upper face. The casting is of magnesium alloy with four engine-mounting pads cast integrally. The air coming from the compressor passes through a delivery annulus and is diffused by six divergent ducts leading to the combustion chambers.

UPSTREAM BURNERS

The combustion system consists of a fabricated outer casing of Nimonic 75, containing six flame tubes of the same material. The six upstream burners are cooled by dilution air trapped in a shroud between the flame tube and casing; they can be individually removed without disturbing other components. The use of upstream burners has allowed a considerable shortening of the combustion system to be made with a consequent saving in weight. Two high-energy sparking plugs are used to ignite the mixture on starting, and interconnector tubes between adjacent chambers ensure flame propagation and pressure balance. The engine operates satisfactorily on either kerosine or wide-cut fuels.

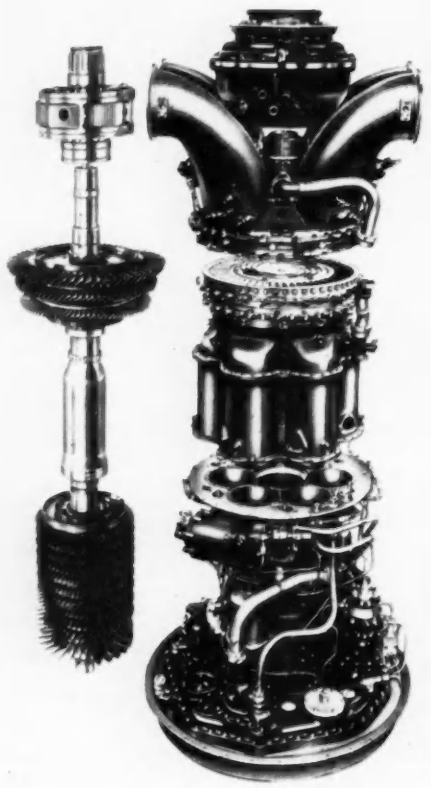
The compressor turbine comprises two rotor discs of Rex 448 steel splined on a hollow forged steel shaft carried by a deep-groove ball bearing. The turbine drives the compressor through internal gear-tooth splines on the turbine shaft engaging with a coupling fixed to the compressor shaft.

The rotor blades are of Nimonic 100 in the first stage and Nimonic 90 in the second stage, being secured by fir-tree roots and locking tabs to the discs. A limited amount of blade tip rock is permitted to relieve blade-root stresses arising from differential expansion of the blades and discs; a Nimonic lacing wire running through the blade roots provides vibration damping.

The inter-stage ring between the first and second-stage rotor discs is of S 80 steel and is located on the shaft by a small-diameter peg. After the second-stage rotor disc, a balancing disc incorporating screwed plugs is provided for the final dynamic balancing of the rotor assembly. Scroll-type deflectors on the interstage sealing assemblies control the passage of cooling air across the faces of the turbine discs. A balance piston splined to the shaft before the first-stage rotor limits the axial loading on the bearing imposed by the turbine thrust.

The first-stage nozzle blading is cast in X40 steel and locked in slots on the inner and outer rings. The second and third-stage nozzles have inner and outer platforms and are bolted to the external casing. A swinging-link attachment on several of the inner platforms carries the interstage seal plate allowing differential expansion and maintaining concentricity of the seals under all conditions.

Mounted coaxially with the compressor tur-



An " exploded " view of the Gazelle, showing the 11 stage axial compressor, the two-stage compressor turbine and free single-stage power turbine.

bine, but mechanically independent of it, is the free-power turbine, which is coupled to the output shaft through epicyclic gearing.

The forged power-turbine disc is integral with a hollow shaft carried on one ball and one roller bearing. The blading is similar to that on the second-stage rotor blades of the compressor turbine. A splined quill shaft engaging on internal splines in the turbine shaft transmits the drive to the reduction gearing.

REDUCTION GEAR AND TORQUEMETER

Because of the construction of the torquemeter, the gearing is not mechanically fixed to the casing; this reduces vibration to a minimum and improves transmission efficiency. A toothed stationary coupling on the magnesium reduction-gear housing is provided to transmit the engine torque to the airframe.

From the turbine, power is transmitted through a quill shaft to a high-speed input pinion supported at the rear end by a ball bearing and, at the front, by a roller bearing. The pinion drives three planet gears, the layshaft of each being mounted on two roller bearings and carrying a planet meshed with the internal annulus gear.

The planet gear and layshaft assembly is carried on roller bearings in a carrier which is integral with the output shaft. The carrier is supported at the front end by a roller bearing and at the rear end by a ball bearing.

The torquemeter, which is mounted in the reduction-gear casing, consists of an annulus gear and a torque ring, each having 15 vanes carrying spring-loaded seals. The annulus gear is located inside the torque ring so that the vanes on each are interposed and spring-loaded against the annular walls between the opposite members by the seals. The spaces between the vanes form the high and low-pressure chambers of the torquemeter and allow peripheral movement of the annulus gear. During normal operation, oil is supplied by a high-pressure pump through inlet ports to the high-pressure chambers, and leaks across the sides of the vanes to fill the low-pressure chambers. The high and low-pressure chambers are separately interconnected by annular passages, and drain-oil escapes through exhaust ports in the torque-ring front cover to the engine sump.

As the torque increases on the annulus gear, the vanes move in relation to those on the torque ring, increasing the inlet port area, and thereby increasing the oil pressure in the high-pressure chambers until the pressure is sufficient to balance the torque. Movement of the annulus gear also enlarges the exhaust-port area to facilitate drainage of the now greater leakage of oil from the low-pressure chambers. By suitable connections to the pressure-balancing chambers the torquemeter is used to give signals for operating safety devices in the event of component failure. Engine tests have consistently shown that the accuracy of the torquemeter over the normal power range is within ± 1 per cent. of the calibrated dynamometer readings.

ENGINE COOLING, PRESSURE BALANCING AND SEALING

Air is bled from the compressor to cool the turbine, to pressurise the balance pistons and bearing seals, and to protect the compressor-inlet guide vanes from icing.

The front face of the first-stage turbine rotor is cooled by air tapped from the support plate. This air passes through an annulus at the outer diameter of the balance piston assembly, pressurises the balance piston and then through a small clearance between the seal plate and the hub of the balance piston, flows across the front face of the first stage disc, through a scroll. The object of the scroll is to lengthen the path of the cooling air across the face of the disc.

Further air is tapped from the tenth stage of the compressor and passes into the hollow shaft through an air transfer shroud carried at the inner diameter of the stator blading. This air, which passes through scrolls on the inter-stage seal plates, cools the rear face of stage-one disc, both faces of stage-two disc, and the front face of the free-turbine disc.

The epicyclic reduction gear and torquemeter.

The power-turbine bearing and the rear face of the last-stage disc are cooled in series with air taken externally through a pipe and filter from stage six of the compressor. Tappings from this filtered supply also cool and pressurise the seals of the compressor delivery-end bearing and the compressor-turbine bearing.

To heat the inlet guide vanes, air is taken externally from the compressor delivery. Stage four is also tapped to supply air, through the hollow compressor shaft, to the compressor balance piston and to pressurise the compressor-inlet bearing seals.

ACCESSORIES

The engine accessories, comprising the electric starter, oil pumps, tachometer generator, speed-sensing unit, centrifugal breather, oil cooler fan and fuel pump, are mounted on the air intake and disposed around the compressor. They are driven by a spur gear train from the front end of the compresor shaft, and the starter motors the engine through the same gear train.

Lubrication is on the dry-sump principle, and the system has been designed to function satisfactorily in any installation position between vertical and horizontal. The engine is supplied with oil from a gear-type pressure pump at 80 lb. per sq. in. which, through a filter, delivers oil to the bearings, gears and torquemeter pump. The pressure pump incorporates a relief valve which by-passes excess oil, and a static head valve, situated between the pump and filter, prevents flooding of the engine by oil under shut-down conditions.

Oil passing through the filter into the oil feed gallery is fed through static head valves to the compressor delivery bearing, the compressor turbine bearings and the front bearing of the free turbine. From the feed gallery, oil is also supplied for the lubrication of the reduction gearing through jets on the planet carrier, and a metered feed provides lubrication to the rear bearing of the free turbine, the output shaft-coupling splines and the reduction-gear bearings. The compressor-intake bearings and the accessory bearings and gears are lubricated by oil taken from the intake side of the torquemeter pump.

Scavenge pumps are provided for scavenging the turbine and compressor bearings, feeding the oil to the auxiliary sump on the front face of the air-intake casing. The oil is then transferred to the main sump on the free-turbine casing and after passing through a strainer and the anti-icing jackets in the air intake, is returned by way of the main scavenge pump to the aircraft lubrication system.

CONTROL

A single lever operating in a Napier fuel-metering unit is the only engine control for normal running; a second lever is required to dump the fuel. A Lucas variable-stroke pump supplies fuel to the metering unit; automatic compensation of the flow for changes in ambient temperature and pressure conditions is provided by the unit, thus obviating repeated control adjustments. During acceleration the variable-datum turbine-inlet temperature and acceleration controls prevent over-fuelling, which might result in surge of the compressor; and a control responding to engine speed varies the compressor-inlet guide-vane setting. This enables the engine to accelerate rapidly, and " slam " accelerations can be made. Should transmission failure occur, over-speeding of the free turbine is prevented by low positive-torque signals from the torquemeter causing the fuel-metering unit to cut off the fuel supply to the engine immediately. With a twin-engine installation, should there be a loss of power due to the failure of one engine, the power of the working engine is automatically increased by an increase in the fuel flow, thus ensuring sufficient reserve power for a controlled landing or continuation of the flight path.

A maximum-torque limitation is incorporated to prevent overloading of the transmission under extremely low ambient temperature conditions or increased rotor pitch angles.

Using closed-circuit television, an engineer at the N.C.B.'s preparation plant at Wath-on-Dearne is able to watch a critical point along the conveyor system as he starts one of the conveyors from the plant control room.

TELEVISION FOR COAL MINES

Industrial television is being used experimentally by the National Coal Board at the Manvers coal preparation plant at Wath-on-Dearne. The installation is being used to view the coal-input conveyor system at a cross-over point where several conveyor belts converge. Should a fault go unobserved at this sector for more than a few minutes duration, tons of coal can pile up and spill over.

The new equipment uses an industrial vidicon camera, a control unit, and a monitor with a 14 in. screen, all of which are produced by Marconi's Wireless Telegraph Company, Limited, Chelmsford, Essex. On the monitor, shown in the illustration, the duty engineer in the control room can see belt working and loading conditions and immediately observe any fault that occurs.

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PLUG-IN RELAYS

The unprotected electromagnetic relay is often the component most prone to damage in a system. For although the performance of the relay depends on preserving a uniform stress in the contact blades they are often unprotected at the time they are most likely to receive damage —during panel wiring. A system has been developed by Clifford and Snell, Limited, Sutton, Surrey, which avoids these faults. Plug-in relays complete with a perspex cover are used. Two typical units are shown in the illustration.

The sockets are slotted and can be slid on to mounting frames. The size of the units is such that 18 may be fitted into an area a little greater than one square foot. Locking screws are provided for use with the plugs when vibration is present. An advantage to the user is the rapid isolation that results from unplugging the relays. Coils are available for up to 400 volts with alternating current, or 250 volts direct current. The relay (type DA2600) is distributed by D. Robinson and Company, Worcester Park, Surrey.

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"WHALES" FOR WATER STORAGE

Large Capacity Collapsible Tanks

Collapsible storage tanks, known as "whales," constructed by the Firestone Tyre and Rubber Company, Limited, Great West-road, Brentford, Middlesex, from two-ply nylon fabric coated with rubber, are in increasing demand for the storage of water on sites.

These whales weigh less than one-tenth the weight of comparable steel tanks and can be transported at a fraction of the relative cost. Up to seven whales can be quickly folded, rolled into small bundles and loaded on to a small vehicle by a couple of men without the use of heavy equipment. Capacity for up to 105,000 gallons can thus be moved cheaply and quickly.

Whales are well suited to rugged conditions, but should damage occur it can be repaired on the site using a simple patching kit. Salt and many other corrosive elements will not affect the fabric and even the metal fittings have a rubber protective coating. They have a built-in system of anti-roll stabilisers which make it possible to use whales even on a 20 per cent. gradient without external supports.

All of the contained liquid can be used because no air is admitted into the whale when the contents are being pumped out. There is, therefore, no possibility of air being drawn into the pump, regardless of the pumping rate.

Developed in the first place by Firestone especially for use in the oil fields, these collapsible storage tanks not only save time and money but have proved their superiority over the usual heavy steel tanks for the storage of oil and water. They are available in capacities from 5,000 to 15,000 gallons.

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SWEEPER-COLLECTOR FOR RUNWAYS

A sweeper-collector for airport runways, demonstrated by Zwicky Limited, Slough, in prototype form on the runways of Farnborough aerodrome last September, is now in production exclusively for airport and arifield use.

Since the orthodox chassis was found not to be suitable, development has centred round a special chassis driven from the front axle, leaving maximum accommodation for the sweeper and hopper. The Ferguson travel engine, with heavy Ford gearbox produced exclusively for this model, gives a running speed of 20 m.p.h. with a sweeping speed of 12½ miles in an hour, in which time 72,000 sq. yds. can be swept clean.

A separate Ferguson power unit is used solely for the operation of the sweeper/collector unit, which includes a water-sprinkling pump. Runway refuse of almost any type, such as surface water, sand and fine dust, is collected partly by sweeping action and partly by suction. The capacity of the container is 3¼ cub. yds. The main brush and the collecting brush are both 10 ft. wide and constructed from piasava bristles. The brush pressure and speed are controlled from the driver's seat.

Fabric water containers of 15,000 gallons capacity folded ready for transport.

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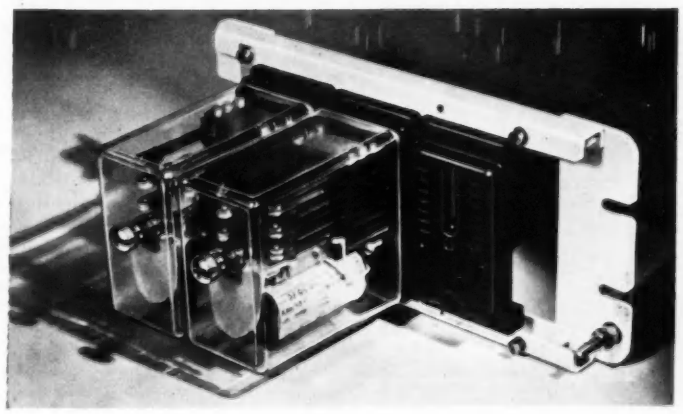
"SPRAYMAT" DE-ICERS FOR U.S.

Under a 10-year agreement signed recently, PacAero Inc. of Santa Monica, California, has acquired the right to manufacture and sell the "Spraymat" electrical system of de-icing, developed by D. Napier and Son, Limited, Acton, London, W.3, in the United States, its territories and possessions. Napier is to supply all the necessary drawings, reports, technical information and assistance needed to enable PacAero to establish both manufacturing and servicing facilities, and will take all reasonable steps to promote the sale of "Spraymat" by PacAero. For its part, PacAero will make available to Napier details of all refinements and improvements which may result from development processes applied to the system by the American company.



The perspex cover over the relays gives protection against mechanical damage and dust. Rapid isolation can be achieved by unplugging the relay.

Book Reviews

NOT A TRAM

The Development of the Trolley Bus. By HAROLD BREARLEY. Locomotion Papers No. 11. *The Oakwood Press, Bucklands, Tandridge-lane, Lingfield, Surrey.* (5*s.*)

Devotees of the tramcar have been known to make wildly circuitous journeys in order to avoid travelling in a bus. When all the trams have gone, they juggle similarly with trolleybus routes, although regarding the trolleybus as a poor substitute. This book shows that although it lacks the mysterious fascination of a vehicle running on rails, the trolleybus has a history which compares well in interest with other forms of electric transport. The author deals primarily with development in the United Kingdom, although his introductory pages describe how the rail-less electric vehicle on the Continent evolved from the early ideas of Werner von Siemens and his experimental vehicle demonstrated in Berlin in 1882.

As a result of his personal experience of the Bradford trolleybuses, Mr. Brearley describes this system at greater length than the others, but the story of how its equipment developed is representative of the course of events in general. He traces the progress from drum controllers operated by hand or pedal to contactor systems and then to automatic acceleration, with some interesting sidelights on the drivers' difficulties with some of the early schemes. The use of two motors with series/parallel control is recalled—a feature which has lapsed in this country although there are some who feel that an intermediate running speed without resistance in circuit would be more appropriate to modern traffic conditions than to those of 45 years ago. A little more might have been said about regenerative braking, on which hopes of considerable economies were pinned at one time. It was tested on several routes, but abandoned because of the difficulty of disposing of regenerated power when no other vehicle was able to absorb it. This was before the time of the grid-controlled rectifier, able to act as an inverter from d.c. to a.c., and if the trolleybus had not been eclipsed to-day by the Diesel vehicle it is possible that regeneration would have made further progress. Some features described by the author, however, are much less likely to be seen again, such as the Mercedes Stoll overhead collection system in which a four-wheel trolley running on top of the overhead wires was connected to the bus by flexible cable.

The treatment in a book of this size is necessarily brief, and a general knowledge of trolleybus practice is required for appreciating the significance of some of the stages in the story of progress. As an outline of development, the book gains much from its 23 illustrations. Here the reader can see the evolution of the trolleybus from an ungainliness which proclaimed it as a hybrid product of the bus and the tram, to a vehicle in its own right which still has a promising future.

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NEW BOOKS

Interavia ABC, 1957. *Interavia (United Kingdom), Limited,* 14 *Clarges-street, London, W.*1. (80*s.*)

This international directory of aviation and aeronautical industries is a valuable complement to *Jane's* covering, as it does, not only the main aeronautical firms but also all the ancillary manufacturers to the aeronautical industries of the world. It is in four major parts. "Alphabet," an alphabetical list of civil and military aviation authorities, airlines, aircraft companies, aero clubs, etc. This is cross referenced to the second part, "Analyt," which is divided into countries and sub-divided by subject classification, giving details of all the activities listed under Alphabet—such as addresses, executives, products, and air line fleets. The third part, "Indicator," is a five-language glossary (English, French, German, Italian, Spanish) of about 1,000 aeronautical terms in each language, and includes cross references to "Analyt," so that it serves also as a buyers' guide. The final section "Who is Where," is an alphabetical list of the world's senior aviation officers and executives, cross referenced to "Analyt." The present volume includes a new section on Eastern Europe, and is correct up to the end of January, with "stop press" amendments up to mid-March. It is in five languages.

Current Carrying Capacity of Small Cables for Domestic and Small Commercial Installations. By R. G. PARR. *The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.* (12*s.* 6*d.*)

This report describes tests carried out to determine the current-carrying capacity of small cables used for domestic and commercial installations. Current ratings corresponding to a 16·7 deg. C. temperature rise are given for four sizes of cable with different coverings and modes of installation, run in single-circuit, double-circuit, three-circuit and four-circuit groups. The relative effects on the temperature rise of a cable in a cold brick wall and of the hardboard used for the specimens are considered in an appendix. A note is also included on the temperature rise of cables on moderate overloads not immediately disconnected by fuses.

A Four-Channel Cathode-Ray Oscillograph with Automatic Brilliance Control. By M. T. CREE. *The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking-road Leatherhead, Surrey.* (6*s.*)

No new principles are involved in this four-channel cathode-ray oscillograph with brilliance control but it is thought that a description of its leading features may be of use to those having occasion to record transient phenomena of long duration (up to 10 seconds), which may include transients too rapid to be recorded with an electromagnetic oscillograph.

Nomographic Representation of Elastic Contact Conditions between Steel Pivots and Sapphire or Diamond Jewels. By G. F. TAGG. *The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.* (6*s.*)

Nomograms are given in report Ref. T/T39 representing the conditions of static elastic conditions between a steel pivot and a sapphire jewel, and also in Ref. T/T48 covering conditions of impact. It had been suggested that it would be useful to have the two major nomograms reproduced in a convenient form, and they are attached to this report.

On the Shelf

By Frank H. Smith

It is gratifying to see that the Minister of Education, in a circular to local education authorities, appreciates the necessity for good libraries attached to the larger technical colleges. But though the range of annual allowances for book purchase is suggested and the need for qualified librarians-in-charge is pointed out, the desirability of offering adequate salaries for those librarians is omitted. So far, the salaries offered when technical college librarians are required are usually ludicrous. A library is as good as its librarian can make it—even with a limited budget—and a good librarian with a knowledge of facilities and sources is worth considerably more than the sum recommended for the purchase of books and periodicals in the circular. When a small organisation lacks a publicity officer, a trained psychologist, a labour relations manager, a quiz-winner and an editor for the various items that are cyclostyled, printed, etc., those duties usually fall on the librarian—and his name is not usually Crichton.

The April *Aslib Proceedings* contains a résumé of the negotiations between the Library Association and Aslib on the subject of the training of special librarians. It has been a vexed question for a long time and there are signs of some agreement at last. The proceedings also contain Aslib librarian's annual survey of special library literature. With its 104 references this is a most useful production and readers should not be confused by the short title at the top of each page, "Bird: Signposts" which is not the start of one of those "association of ideas" parlour games.

Until some legislation is introduced to control the birth of printed matter it will continue to multiply at a rate faster than library shelves can cope with it. Microfilming is a partial solution to the problem and any librarian contemplating microfilm should read an article in the *Unesco Bulletin for Libraries*, February-March, 1957. (Unesco, 19 Avenue Kleber, Paris 16e, or H.M.S.O. 1*s.* 8*d.* per copy, 16*s.* 6*d.* annually). It is entitled "Use of microfilm for periodical storage," and though the idiom is American the figures, graphs and subject matter would make sense in any language.

The projected National Lending Library for Science and Technology is dealt with in a paper by Dr. D. J. Urquhart in the March number of the *Journal of Documentation* (Aslib). The progress of this library is of the greatest interest to all concerned with science, technology and industry and Urquhart's article should be read by anybody who feels that he has ideas or suggestions to put forward. The library and information world contains many individualists who believe they have the clues to the ideal library service. The chance now presents itself for them to put their ideals forward and have them critically examined and either adopted or discarded.

The Engineering Institute of Canada (2050 Mansfield-street, Montreal 2) announces that it is extending its publishing activities. It is producing "worthwhile biographies" and the first two are of the brothers Shanly (Walter and Francis) and Sir Casimir Gzowski. Walter Shanly and Gzowski were both vice-presidents of the E.I.C. and contributed to the making of Canada's present eminence. The E.I.C. is also restarting its *Transactions* which were interrupted in 1930. These will contain more specialised papers than those in the *Engineering Journal*, which continues to appear.

American aeronautical journals issue an annual trade directory and buyer's guide to the industry. *Canadian Aviation* has now caught the habit. The April number contains a 142-page supplement giving a classified directory of suppliers to the aeronautical industry in that country and, apart from its usefulness to those interested, it is quite a revelation of the extent of the industry in the Dominion.

Attempts to spoon-feed librarians are always welcome. The latest—*Technical Bookguide*—will save a lot of hunting through booklists each month. No. 1 of Volume 1 appeared in April and lists new books under broad subject headings. There appears to be no indication of how these headings are chosen and the U.D.C. champions will, no doubt, have something to say about that. They appear to be adequate at the moment. The lists are supplemented by articles surveying the literature of the month and a reader service is offered.

A casual glance at the lists reveals at least one instance of the danger of ordering from a title. *Colloquia on Ageing* is described as for medical practitioners, etc. How easy it would be for the inexperienced metallurgical librarian to slip up on that one! Hansom Books, of 21 Lower Belgrave-street, London, S.W.1, publish the guide at 8*s.* per annum, post free.

It would seem that Miss Nancy Mitford's influence is greater than I thought. A new book published by Wiley (*Nonparametric Methods in Statistics*, by D. A. S. Fraser) has a section on "Limiting Distribution of U Statistics."

PLANNING FOR RESEARCH

Centralised Facilities for Piston Engines and Gas-Turbines

Research work requires as much planning as any other aspect of factory operations. Especially is this the case with those concerns who wish to expand both in range and quality of product. Research cannot be carried out without facilities of some sort, and it is naturally better that these should be planned rather than grow up in a haphazard fashion.

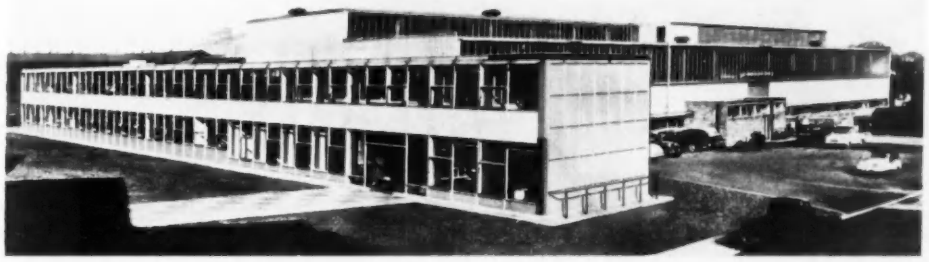
Ruston and Hornsby, Limited, Lincoln, have been suffering from lack of accommodation for some years in their six factories which are spread through the city. In these factories as far as possible, the introduction of a research section was made where facilities were available, but with the rate of development and expansion, such facilities became more and more difficult to obtain. It was therefore decided to construct a central research building, where all the sections could be co-ordinated under one roof. In order to gain ideas as to what form this building should take, a tour was made of similar large engineering plants in Germany, Switzerland and the United Kingdom to discover what was best in each of their research departments. The building that has now been erected at Lincoln is the outcome of the accumulated knowledge.

In ground plan it is like a square U, the two arms being made up of test bays, and the connecting link of the associated offices and laboratories. It is hoped by having this centre that increased efficiency will be obtained as well as economy, particularly in the use of manpower. Other economies that can be effected are in the provision of maintenance apparatus and in the exchange of ideas between the personnel of different sections. The total capacity of the new building will be for 40 high-speed engines, 10 medium-speed engines and five gas-turbines, although the latter section has provision for increasing to possibly seven. Outside the building are track lengths of different gauges where any size of Diesel locomotive can be mounted. The high-speed engines are divided into ranges of from 0·5 to 2·5 litres, 2·5 to 7·5 litres and 7·5 to 13 litres. Test beds for 12, 14 and 14 engines are provided, respectively, for these classes. Together with the machine shop, these test bays form one complete arm of the U. In the other arm are the heavy and medium engine test bays for which there are beds to accommodate five engines up to 540 b.h.p. and for four engines between 1,340 and 2,410 b.h.p.; at the extreme end is the bay for the gas-turbines and the combustion rig work. The power of the engines is absorbed by dynamometers, alternators or Heenan and Froude water brakes.

In addition to the open bays there are provided a cold chamber and a hot chamber for test operations at any temperature ranging from −40 deg. F. to +130 deg. F. Prestcold equipment has been used to chill the cold chamber. In it, four small high-speed engines can be installed, but space in the hot chamber only allows for two. Between the two arms of the U are the stores, the cooling water pump house and boiler house (in which a Ruston packaged boiler supplies the space heating and process steam) and the electrical sub-station for the whole research centre.

Between the test bays and the offices is a sound, insulated wall and a corridor, to prevent noise being transmitted to the laboratories. The design has been taken to the extreme in that separate foundations for the two blocks have been used, and flexible joints at the roof level. The result is that there is virtual silence in the laboratory and office block. On the upper corridor are four inspection windows, from which the running shops can be observed. Outside the building and adjacent to the turbine combustion test rig bay, are the oil storage tanks, of which there are five. The total cost of the building was approximately £300,000, half being the cost of the actual structure, and the remainder of the additional equipment installed.

The architect for the office and laboratory block was Mr. J. C. Clavering, F.R.I.B.A., and the consulting structural engineers T. Bedford and Partners. Consulting engineers for the building foundations of the test area were Clarke, Nicholls and Marcel, and the quantity surveyors were Thurgood, Son and Chidgey. The planning and co-ordination was carried out by the engineering department of Ruston and Hornsby, Limited, and the main contractors for the building were William Moss and Sons, Limited, Loughborough. At present there are 165 people employed in the centre, of whom 40 are engineers, technologists or draughtsmen, and 12 administrative. Provision has been made in the planning for future developments on nuclear projects.

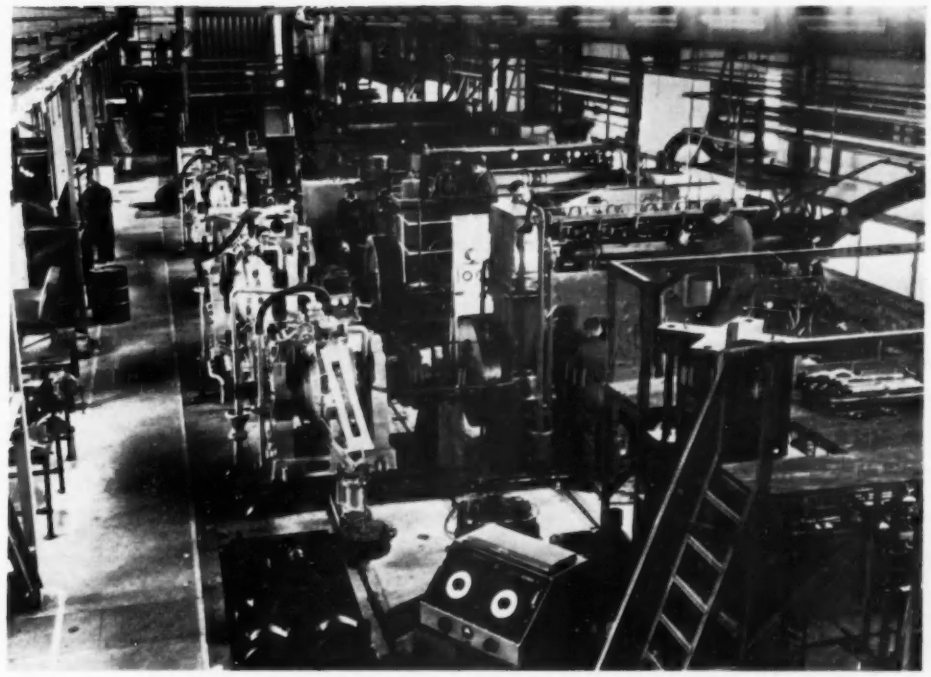


Research previously carried out in different factories has been centralised in Ruston and Hornsby's new building.

Research and development now in progress in the engine division includes work on the new range of air-cooled engines, and such fundamental problems as the stresses in parts of prototype models. Torsional vibrations of crankshafts are always checked before a new model goes into production, and work is done on vibrations generally. Pressure charging, both by mechanically-driven and exhaust-driven blowers, forms quite a large section on its own. One piece of work that has recently been concluded is the conditioning of engine exhausts, particularly for use in connection with underground locomotives, and Buxton flame-proof certificates have successfully been obtained for these.

On the gas-turbine side, fuels are one aspect of investigation, together with various forms of combustion chamber to give better performance. One form has been developed to enable a gas-turbine to run successfully on CTF 200.

Another development on the gas-turbine is an automatic control system which has just completed its preliminary trials. With the aid of this, a set can become a true emergency standby in that it will automatically start if a mains failure occurs, and will stop as soon as the mains supply is restored. The turbine is fitted with standard controls for gas-oil running, which consist first of a control unit for either manual or automatic operation, which switches in a starter motor and igniter and regulates the fuel flow to the burner until the alternator has reached full speed. The second control unit takes over when full speed has been reached, and a centrifugal governor acts as the operating agent. Droop is normally set at 3 per cent., giving an idling speed of 1,545 r.p.m. for a full load speed of 1,500 r.p.m. The third item in the control system is an acceleration limiter to govern the fuel flow when load is suddenly applied to, or removed from, the turbine. When a sudden application of load occurs there is a temporary fall in output speed and the engine passes out of control of the governor. The acceleration limiter then comes into action and controls the compressor acceleration until the output shaft



There is provision in all for some 55 test-beds for engines of different types and size. Shown here is part of the heavy medium-speed bay.

once more approaches full speed and the governor takes over. The turbine can accelerate from idling to full load conditions in 10 seconds. Blow-off valves fitted in the compressor delivery ducting are automatically opened when load is removed to allow excess air to escape while the compressor is decelerating down to idling sped.

The starting equipment for automatic control consists of a mechanical control unit and an electrical system of relays in a control cabinet. The operation of the equipment, both electrical and mechanical, is controlled by an electric motor driving a camshaft. There are eight cams on this shaft which operate electrical contacts, and also a fuel control cam. This last actuates a pilot valve and servo piston mechanism regulating the fuel flow to the burner. After the start-button has been pressed, the motor rotates the camshaft through 270 deg., taking 90 seconds to do it. On shut-down the camshaft is rotated (in the same direction) back to its starting position.

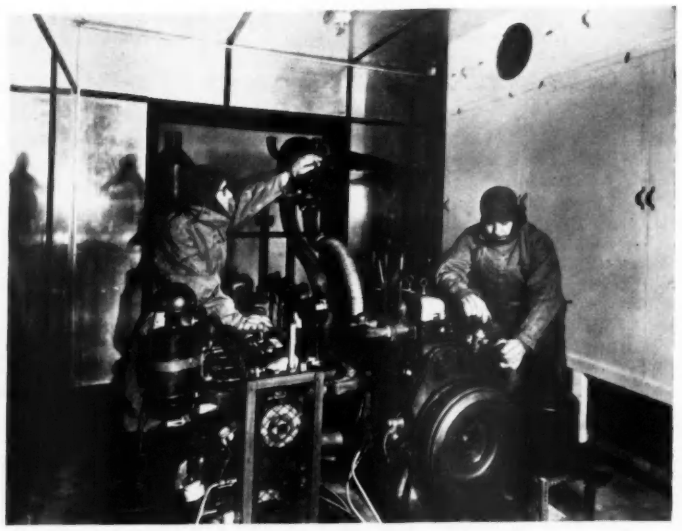
The electrical control system, which is sequence operated from the cams, was manufactured by the Edison Swan Electric Company, Limited. The auxiliaries are first started, then the shaft is rotated, fuel injection commenced and the igniter operated. On shut-down, the motor driving the lubricating system continues to run for a set period to allow the turbine to decelerate. Automatic safeguards are included for lubricating oil failure, flame failure, starter motor contactor failure, control equipment supply failure, high lubricating oil temperature or high maximum gas temperature. The operation can also be manually controlled without any modification.

★ ★ ★

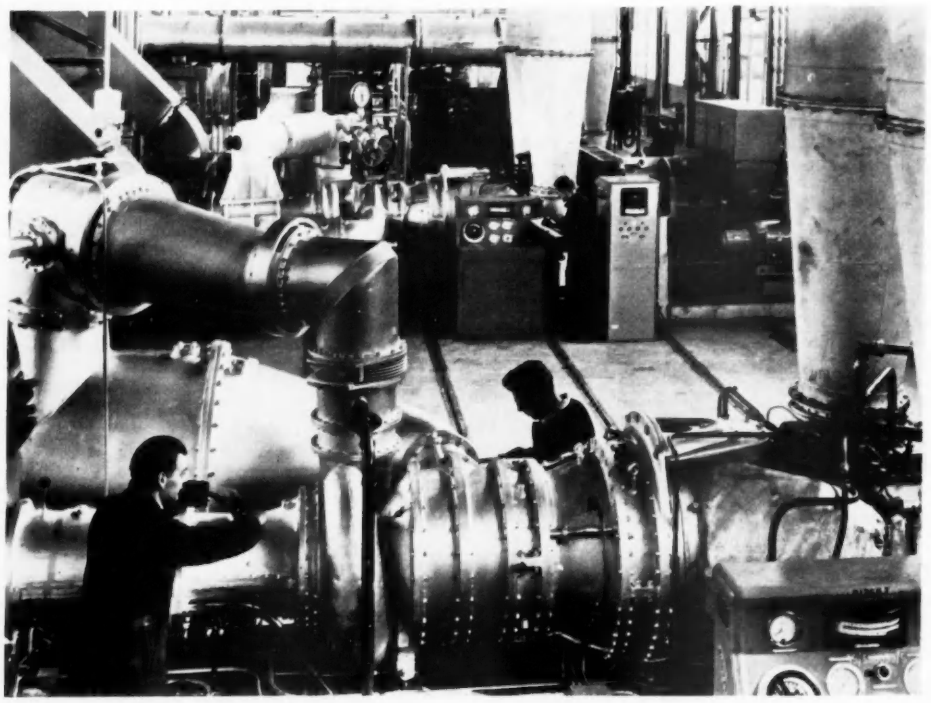
IMPROVED MORTAR

" Plycomor " is an additive that has been produced by British Bitumen Emulsions, Limited, Dundee-road, Trading Estate, Slough, Buckinghamshire, for mixing with mortar to improve its plasticity and workability. It is claimed that when Plycomor has been added there is no necessity for any lime. The action is said to be that microscopic air bubbles are introduced into the mix, which, distributed evenly throughout, form separate airlocks and have the effect of increasing the bulk. When the mix has been applied and set, the air cells act as cushions against stresses and strains caused by expansion and contraction due to varying weather conditions and, as a result, there is less crazing and cracking. It is further claimed that the mix is tougher, there is an increased resistance to frost, water absorption is reduced, and sand can be used for pointing work.

(Right) In the cold room at Ruston and Hornsby's, engine performance, particularly starting, can be investigated at temperatures down to −40 deg. F. There is also a hot room for operation up to +130 deg. F.



(Below) Gas-turbines form a major section of research. The one in the foreground is for running on C.T.F. 200 and the one in the background is equipped with fully automatic starting and control apparatus.



ATOMIC REVIEW

Central Core

No discussion of atomic energy can proceed far without reference to nuclear reactors, which may reasonably be regarded as the core of the matter. The following notes deal generally with recent news of reactor developments and with power plans and programmes. An article on Britain's fast breeder reactor at Dounreay appears on page 610, where reference is also made to the prototype reactor for the Admiralty's nuclear submarine, and to DMTR.

Euratom Plans

Last week the " Three Wise Men of Euratom " presented their report on European atomic energy prospects and outlined a 6,000 million dollar (£2,140 million) nuclear power project for the six Messina countries—France, Germany, Italy, Holland, Belgium and Luxembourg—to be completed by 1967. Its main purpose is to reduce the dependence of these countries on Middle East oil imports, now equivalent to 100 million tons of coal a year and likely to be double by 1967 and treble by 1977. The report, *A Target for Euratom*, calls for an immediate start on a 10 year 15,000 MW programme of nuclear power station construction in the six countries. (Britain's aim is 6,000 MW of nuclear power by 1965.) Of the total sum, £1,800 million will be devoted to nuclear power plant, and the remaining £700 million will be spent on the initial fuelling of the reactors. It appears that part of the nuclear plant, amounting to some £400 million, is to be imported, and Britain is likely to secure a major share in this work. Two reactor systems have been suggested: the natural-uranium fuelled gas-cooled graphite-moderated reactor similar to those at Calder Hall, and the pressurised-water cooled and moderated reactor using a slightly enriched fuel; the United States submarine Nautilus and the Shippingport power project now nearing completion employ pressurised-water reactors. The report stated that the cost of electricity produced by the British and American types of reactor ranged from 11 to 14 mills (about 1*d.* to 1¼*d.*) per kWh, while in Europe conventional station power costs were from 11 to 12 mills per kWh. Favourable comment was also made on the Canadian natural-uranium heavy-water moderated reactor.

Originally, owing to the high cost of enriched uranium (from diffusion plants and otherwise) and the fact that Continental Europe had no diffusion plant, there had been considerable opposition to projects dependent on enriched fuels, but the willingness of the Americans to supply enriched uranium at about one-third the anticipated cost of locally enriched materials and the prospect of later using plutonium produced in the Euratom reactors for enrichment have given rise to a change in outlook. The French, however, who are themselves building gas-cooled natural-uranium reactors, are understood to have doubts concerning the new policy. It is worth noting that, although the lower capital cost of the pressurised-water reactor is quoted as balancing its higher fuel costs over a 15 year period, the cost of the Shippingport PWR appears to be rising (see later note).

The Three Wise Men are M. Armand, director-general of the French State Railways and President of the French Atomic Energy Commission;

Dr. Franz Etzel, West German vice-president of the European Coal and Steel Community; and Professor Francesco Giordani, President of Italy's National Research Council. The background to the report and a general survey of the international atomic situation appeared in Atomic Review last April 19.

Nuclear Power Plant for Germany

Brown, Boveri and Company, Mannheim, and Friedrich Krupp, Essen, have entered into a contract with Arbeitsgemeinschaft Deutscher Energieversorgungsunternehemen zur Vorbereitung der Errichtung eines Leistungsversuchsreaktors (A.V.R). e.V., Düsseldorf, for the design of a nuclear power plant of 15 MW net electrical output. This is the second contract for a German nuclear power plant. Several weeks ago, Rheinisch Westfälische Elektrizitätswerke (R.W.E.) announced the construction of a nuclear power plant of similar output to be built by the American-British group of A.M.F.-Mitchell. Whereas the R.W.E. plant will be equipped with an A.M.F. boiling-water reactor, the A.V.R. contract specifies a reactor developed in Germany. The reactor will be of the homogeneous, gas-cooled and graphite-moderated type using ceramic fuel elements made of sintered uranium carbide and graphite. The fuel elements are loaded from the top and removed from the bottom of the reactor vessel. The reactor will be controlled by changing the uranium load and the coolant flow. No shim or control rods will be used. It is hoped to achieve a high rate of burn-up by re-sintering the elements at intermediate intervals thus curing the damaged structure. This concept is said to allow much higher operating temperatures—steam at 980 deg. F. (527 deg. C.)—than any existing reactor. In the opinion of Arbeitsgemeinschaft Düsseldorf, this reactor will operate very economically. It is believed that the power costs will compare favourably with the costs of a conventional coal-fired plant, once commercial operation has been attained. The location for this plant has not yet been selected. It is hoped that a pilot plant will be ready for operation in 1960. The Arbeitsgemeinschaft Düsseldorf is composed of the following utilities: Stadtwerke Bremen A.G., Stadtwerke Duisburg, Stadtwerke Düsseldorf, Kommunales Elektrizitätswerk Mark A.G., Hagen, Elektrizitätswerk Wesertal G.m.b.H. Hameln, Stadtwerke Hannover, Elektrizitätswerk Minden-Ravensberg G.m.b.H., Herford, Stadtwerke Kiel und Wuppertal-Stadtwerke A.G. Brown, Boveri and Company A.G., Mannheim, like British Brown-Boveri Limited, are associated with Brown, Boveri and Company, Limited, of Baden, Switzerland, which is also the research centre of the Brown-Boveri group.

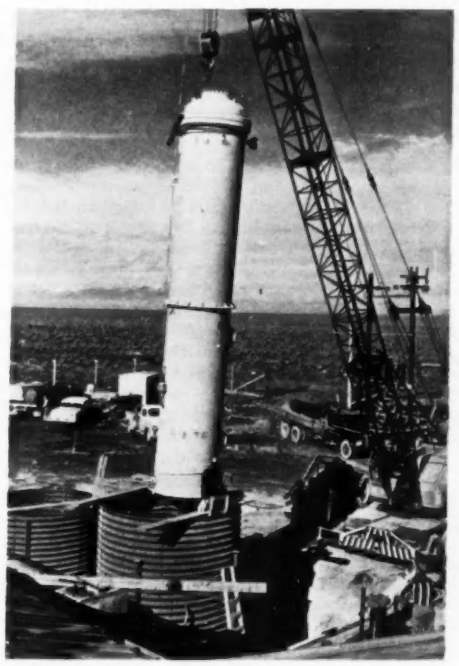


Fig. 1 (left) Lowering the reactor-core tank into the cavity liner of the Organic Moderated Reactor Experiment (OMRE), a reactor using an organic liquid as both coolant and moderator.

Fig. 2 (right) Induction heating coils are installed at the bottom of the main core vessel for OMRE now being built by Atomics International Incorporated for the U.S.A.E.C.

United States Programme

In his address at the opening of the APPR, Mr. Lewis L. Strauss, chairman of the U.S.A.E.C. predicted that, by the end of 1957, 5 or 6 nuclear power plants would be in operation in the United States, and that by the early 1960's at least 21 plants would be producing power.

United States Projects

A table listing the American power reactor projects undertaken to date was published in Atomic Review on April 12, together with details of the reactor system for the newly announced Northern States plant. The types of reactor system adopted for certain other recent projects have also been made public. The New England Electric System has approved the construction of a 200 MW power plant based on an advanced form of pressurised-water reactor and costing about 50 million dols.; it is due for completion by 1963-64. Middle South Utilities are considering building a 15-30 MW station using an advanced reactor system; an Atomics International design for a sodium-cooled uranium 235-thorium-uranium 233 breeder reactor is among five proposals received. Pacific Gas and Electric are reported to be submitting a proposal for a pressurised or boiling water reactor under the third round of the Power Demonstration Reactor Programme. The reactors under consideration for the smaller of the two plants envisaged by the Ohio River Valley group of companies headed by the American Gas and Electric Company (see Atomic Review, March 15) are said to be: a graphite suspension reactor proposed by Babcock and Wilcox; a natural-uranium heavy-water moderated liquid-metal cooled reactor proposed by Nuclear Development Corporation of America; and an advanced sodium-graphite reactor with ceramic fuel elements proposed by General Electric.

Rising Cost of Nuclear Power in U.S.

Startling increases in the capital cost estimates for nuclear power projects were disclosed during the recent hearings before the U.S. Joint Committee on Atomic Energy.

Shippingport PWR—Costs are up from 37·5 to 55 million dols. Power from the first core will cost 75 mills per kWh instead of the 52 mills previously estimated.

Consumers Public Power District, Nebraska.—Costs have risen from 24·3 to over 40 million dols.

Wolverine Electric Cooperative.—Construction costs are up 25 per cent.

Rural Cooperative Association, Elk River.—Reactor and superheater costs alone have risen by 2 million dols.

Yankee Atomic Electric.—Costs are up by "a substantial margin" from the 35 million dols. previously estimated.

Commonwealth Edison, Dresden Plant.—General Electric entered into a contract at 45 million dols. but are now believed to have misgivings about this figure.

Consolidated Edison's cost estimates for their Indian Point plant have also risen from 55 to 70 million dols., but the increase in this case is due not only to increasing materials costs but also to design changes. A new core, designed by Babcock and Wilcox, will raise the power level from 236 MW to 275 MW, 163 MW from the reactor and 112 MW from the oil-fired superheater (previously 140 MW and 96 MW, respectively). The old seed-and-blanket concept has been replaced by a uniform core of Zircaloy-2 tubes containing 97 per cent. thorium oxide and 3 per cent. uranium oxide at top enrichment.

Radiation damage data on metallic thorium and uranium-zirconium alloy plates developed by Babcock and Wilcox is given as the reason for the change. In addition, a spherical containment shell, which will be half underground, has been adopted.

Organic Moderated Reactor

Nearing completion at the National Reactor Testing Station in Idaho is the Organic Moderated Reactor Experiment (OMRE). This reactor, an experimental unit in the United States, Atomic Energy Commission's programme for developing economic nuclear power, utilises an organic fluid, such as diphenyl, as coolant and moderator. It is said to be promising for small and medium-size power plants and for marine propulsion because of its simplicity of operation and the relatively high-temperature heat that can be produced in a low-pressure system. OMRE, which is being built by Atomics International Incorporated, is designed to produce 16 MW of heat. This heat, which would normally be used in commercial plants for the production of process heat or electricity, will for the experiment be dissipated by an air-blast heat exchanger. Coolant temperatures will run from 500 to 700 deg. F. during the operation of the reactor. The core of the reactor will consist of plate-type fuel elements containing uranium highly enriched in uranium 235, and the organic coolant. The use in a reactor of an organic compound such as diphenyl offers a number of advantages which stem from the inherent properties of the materials: it has a high hydrogen content which makes an excellent moderator; it boils at relatively high temperatures compared with water so there is no need to maintain the compound under high pressures; it causes negligible corrosion with standard materials of construction; it does not react readily with uranium; and it becomes only slightly radioactive on exposure to nuclear radiation. Preliminary work on the OMRE was started late in 1955 and it is expected to cost about 1,800,000 dols., shared between the A.E.C. and Atomics International. If the OMRE is

successful a nuclear power reactor of the same type is planned for the City of Piqua, Ohio. This would have an electrical capacity of 12·5 MW and would be built under the A.E.C.'s Power Demonstration Reactor Programme. Atomics International have been named design agents for the Piqua plant.

Sodium Reactor Experiment

The United States Atomic Energy Commission announced on May 1 that self-sustaining nuclear fission was achieved on April 25 in the Sodium Reactor Experiment (SRE). This is a small-scale experimental atomic power project being developed for the Commission by the Atomics International company. It is located near Los Angeles. The SRE is said to be the first sodium-cooled thermal reactor to go into operation. It uses a graphite moderator and liquid sodium as coolant. After a testing period the SRE is expected to produce enough heat to generate 6·5 MW of electricity, which will be used by the Southern California Edison Company.

Ceramic Fuel Reactor

An experimental reactor using ceramic fuel elements is reported to have operated successfully for the first time in the United States. Said to resist corrosion and distortion, ceramic fuel elements are also under investigation as the basis of future development of the gas-cooled reactor.

EBWR Progress

The official opening of the EBWR took place at Argonne National Laboratory on February 9. The reactor had, in fact, gone critical several weeks earlier (see Atomic Review, February 1) and reached full power on December 29, but the occasion did mark the start of the first extended full power test run. The reactor is now operating well on natural circulation of the coolant water, but more power will be extracted with forced circulation when pumps have been installed later in the year. Even better performance should be achieved in 1958 when the moderator will be changed to heavy water, provided the minimal leakage—about 2 lb. per day—can be overcome. The cost of power from EBWR in its present condition is estimated at 30 to 35 mills per kWh. If its output were increased to 40 MW (thermal) and 10 MW (electrical), which is twice its rated power level, as its designers believe possible, costs would fall to about 20 mills per kWh, compared with 12 to 15 in an equivalent sized conventional plant. Forced circulation of the coolant would reduce costs slightly further. Capital cost of EBWR, excluding research and development and fuel charges, is quoted as 4 million dols.

THUD

A programme of research on the use of a fuel-moderator system based on thorium-uranium-deuterium (known briefly as THUD) is now under way at the Argonne National Laboratory. A core comprising thoria-urania ceramic pellets submerged in heavy water has been inserted in the reactor BORAX-4 and exponential experiments are in progress. A zero-power reactor is soon expected to be ready, and later a similar core may be tried in the boiling-water reactor EBWR.

Irrigation

It has been reported that the Californian State Assembly has voted support for a feasibility study into the use of nuclear power plants for pumping water for irrigation purposes. Water would be pumped from the Feather River in Northern California over the Tehachapi mountains into Southern California.

Changes in NPD

Technological advances made since detailed planning of the Canadian Nuclear Power Demonstration reactor (NPD) began have called for various design modifications. Construction work has therefore been temporarily discontinued while the improvements are incorporated. The output, 20 MW of electricity, and the reactor system (natural uranium fuel with heavy water moderator) will remain unchanged. It is now expected that the station, which is located at Des Joachims, Ontario, will be completed by 1960. So far only the foundations have been prepared. The announcement was made jointly by Atomic Energy of Canada Limited, the Hydro-Electric Power Commission of Ontario, and the Canadian General Electric Company, Limited, which are partners in the project.

Small Power Units

Speaking in Baghdad recently (see Atomic Review April 12), Sir John Cockcroft said that in Iraq where oil and natural gas was abundant and where electrical demand was in any case not so great as to warrant the building of a nuclear power station on the United Kingdom scale, the cost of nuclear power would at present be much greater than the cost of electrical power from oil. In neighbouring countries there were likely to be regions remote from oil supplies or hydro-electric power where nuclear power might be attractive at a fairly early date. Sir John believed that nuclear power units developing from 10 to 30 MW of electricity would be required. These could now be built. A smaller version of the Calder Hall power station, developing 30 MW of electricity would be possible. For smaller outputs a different kind of nuclear reactor would be preferred and work on several possible systems was in progress. The cost of power from such stations in the United Kingdom would probably lie between 1½*d.* or 2*d.* per unit—about the same as the cost of power from Diesel stations, though an accurate estimate could not be given.

Reactor Fuels

Subsequently, Sir John gave a lecture to the Istituto di Studi Parliamentari in Rome, where he spoke on the United Kingdom nuclear power programme. In particular, he discussed the cost and availability of nuclear fuels. The cost of uranium fuel elements in their final form, sheathed in a magnesium alloy, was not more than £20,000 a ton. Furthermore, the uranium rods would accumulate plutonium, so at the end of their life they are likely to be worth about £5,000 a ton. Thus the net cost of the uranium would be less than £15,000 a ton. One method of using plutonium would be to recycle it through the reactors, mixing it with some virgin uranium and part of the depleted uranium. This meant that the feed of natural uranium could be reduced by a factor of about three. Uranium supplies had improved in the last two years and Mr. Jesse Johnson, Director of Raw Materials of the U.S.A.E.C., had stated that the Western World would have an output of 30,000 tons a year of uranium oxide, when present plans had materialised. If half of the 30,000 tons a year were devoted to electrical power production it would enable the installation of nuclear power stations to proceed at the rate of 10,000 MW a year. This should be more than adequate till the 1970's.

He also observed that, although both sodium-graphite and pressurised-water reactors would by 1960 have lower capital costs than the 1960 gas-cooled reactor, their fuel costs per ton would be appreciably higher—perhaps by three times. High cost would follow from the necessity of using an enriched fuel and zirconium or niobium fuel cans.

COMPONENTS FOR AUTOMATION

Some overlapping of exhibits has naturally occurred at the various exhibitions of the year featuring electronic devices. Some firms have taken the opportunity to feature different sections of their output at different exhibitions, other firms have not. From its title, the Instruments, Electronics and Automation Exhibition clearly trespasses on ground previously covered by existing exhibitions. The main feature that distinguished it was its emphasis on automation. Consequently it is this feature that will be considered in the following article.

Automation, like so many vogue-words, is used by many people in many different ways. Its ultimate realisation, the automatic factory—*sans* Tom, *sans* Dick, *sans* Harry—does not lend itself readily to presentation at an exhibition. But the individual components do. However, the term " individual component " takes on a new meaning in this context and includes digital and analogue computers, which are more often considered as isolated devices rather than as parts of a complex system.

ELECTRONIC ANALOGUES

A simulator in which the operator can manipulate a complex piece of apparatus without suffering the uncomfortable consequences of a mistake was displayed on the stand of the Solartron Electronic Group, Limited, Thames Ditton, Surrey. A radar simulator, consisting of a flight-control panel and a computer system, is linked with a version of " Eucrates."

Eucrates is the name given by the company to a device that is capable of learning and taking decisions as a result of its learning. The device has been further developed to give a more comprehensive performance and is produced in a variety of forms under the general name of " cybernetics controllers." At the exhibition the operator was confronted with a radar display on which were represented two aircraft, one under his control, and a second under the control of Eucrates. An electromechanical analogue computer simulated the behaviour of the aircraft and ensured that they did not exceed the practical limits of controlled flight. Thus, for example, it was impossible to make an abrupt turn at an angle instead of a proper sweep. The operator assumed the role of pursuer, and Eucrates caused the aircraft it controlled to take evasive action. Information is fed into the computer which forms part of Eucrates and from the results the instrument makes its decisions. The circuits are arranged so that the cybernetics instrument is always slightly better than the human operator. Thus, as the skill of the operator increases, the task demanded of him becomes more complex. In other words, the device trains the operator.

Cybernetics controllers may be used in a wide variety of circumstances. A typical industrial application is in the controlling of the rate of flow on a conveyor belt to suit the speed of the individual worker being fed by the belt. The controller takes account of the changes in

TABLE.—Characteristics of Digital Computers Shown at the Instruments, Electronics and Automation Exhibition

—	Metrovick 950	Stantec-Zebra	National-Elliott 405
Addition time	3 millisec.	312 microsec.	100 microsec.
Multiplication time	8 millisec.	11 millisec.	3·3 millisec.
Size of " word " stored	32 binary digits	32 binary digits	32 binary digits
Main store	4,096 words on magnetic drum	8,192 words on magnetic drum	4,096 words on magnetic drum or 16,000 words on magnetic disc or 300,000 words on magnetic film
Computing store (rapid access)	Tracks on the drum	Tracks on the drum	Nickel delay lines
Approximate basic price	£18,000	£18,000	£35,000 (with magnetic drum only)

productivity that the worker displays and regulates the feed accordingly.

A second simulator that can be used to train operators was shown on the stand of Elliott Brothers (London), Limited, Boreham Wood, Hertfordshire. The theme of the display was integrated system design for large industrial processes. Speaking at a recent luncheon, Mr. Leon Bagrit, managing director of Elliott Brothers, said that there appeared to be an "indifference to progress" in Britain and contended that if Britain was to compete successfully in world markets then automation should be introduced into industry more rapidly. The display showed how automation could be applied. Among the exhibits was a reactor control system. To simulate the operation of the nuclear reactor itself, a ND181 reactor simulator is coupled into the system. This is an analogue computer in which the variables of a reactor—neutron flux, temperature, etc.—are represented by electrical quantities. A complete range of instruments enables the operator at the control panel to gain experience of operating a nuclear power station without the shadow of a mushroom shaped cloud cast on his every move. Graphic panels were used to explain the function of each instrument. In addition to reactor instrumentation, the more conventional equipment found in all generating stations where steam turbines are used to drive large alternators was represented. Also two conventional sources of energy—coal and oil—were shown on the main panel as alternatives to the reactor heat exchanger for a source of steam.

Other panels were concerned with the supply and feed-in of coal and oil to the plant. A continuous belt installation, with electrical weighing, for the handling of coal was shown, partly in model form. The electrical outputs from the load cells of the weighing device were converted to digital form for the operation of data-processing equipment and for final presentation on an electric typewriter. A similar installation for the oil supply—measuring levels, temperatures, etc., in the storage tanks—was also shown. The instrumentation for the turbo-alternator included automatic continuous scanning and read-out, in digital form, of a large number of bearing temperatures. Again, records were presented by electrical typewriter, provision being made for the sounding of an alarm should any reading exceed its safe limit.

(Left) The Metrovick 950 is a medium size digital computer that uses transistors extensively.

(Below) The National-Elliott 405 data processing system during installation in the Norwich city treasurer's department.

REAL TIME PROBLEMS

An analogue computer was also displayed on the stand of Short Brothers and Harland, Limited, Belfast. A small general purpose machine was shown working on aerodynamic problems. Analogue computers find application in problems where an accuracy of the order of 1 per cent. or less is required. They are particularly useful in aircraft design where they can be made to simulate the flight of an aircraft which is still in the drawing-board stage. Thus it is no longer necessary to build an aircraft before discovering whether it will fly. Additional circuits can be incorporated to simulate air-pockets, engine failure, or the change of conditions as the wheels touch the ground. The computer is also used in chemical and general engineering problems.

Real and imaginary time scales are no longer the sole property of poet and mystic. For they have now become part of the day-to-day techniques of analogue computation. By compressing the time scale of the electrical analogy of the problem being solved, the results may be achieved more rapidly. By expanding the time scale, greater accuracy may be achieved. By operating on a real time scale various physical components from the system under investigation can be incorporated to work in conjunction with the computer.

A difficulty with real time problems is that if they are of a long duration residual drifts in the values of computer components introduce errors. A newly devised circuit modification that is being incorporated in all the Short computers in production minimises the effect of these drifts. Previously a drift-correction system was in use which operated only during intervals between problems. This meant that during continuous operation the computer was corrected for drift only up to the moment when computation started. The stability of the amplifiers and power supplies enabled the computer to be operated in this way for periods of up to 20 minutes before serious error occurred. However, because of the increasing use of the computer in real-time simulation where periods of an hour or more are desirable, a new form of drift correction has been introduced. Tests show that amplifier input drift with the new system is of the order of 50 microvolts during a normal day's work. This compares with a previous drift of the order of millivolts.

MEDIUM-SIZED COMPUTERS MORE FLEXIBLE

Three companies were exhibiting digital computers. Each might be described as a medium-sized machine. Although the absence of giant computers may be accounted for by the difficulty of housing such machines in an exhibition, it does seem that the companies new to the digital computer market are concentrating their efforts on low-priced machines. This trend is the result of several factors. Firms that have not used computers before are generally more ready to speculate on a low-priced machine. Improved flexibility is gained by a firm having about three medium-sized computers working independently. Other concerns already using a large computer find a need for a small computer for use by specialist departments who would otherwise waste a considerable amount of time awaiting their turn on the large machine. Small research laboratories—of which there are many—cannot afford a large machine but can do a lot of useful work on a fairly cheap medium-sized machine. In instances where a large concern needs a giant computer and cannot solve its problems without one, it would appear that no alternative exists but to buy or hire an American machine.

The table opposite gives some degree of comparison between the machines displayed at the exhibition. It is difficult to make an exact comparison because these are general purpose computers that can be tailored to suit particular operating conditions, and consequently performance often depends on the manner in which the computer fits into a system.

The Stantec-Zebra, manufactured by Standard Telephones and Cables, Limited, Connaught House, Aldwych, London, W.C.2, is noteworthy for its novel programming philosophy. The design was carried out in conjunction with the Netherlands Post Office who suggested the original idea. The normal code used within the machine is built up from "operational digits," each of which produces a simple logical operation within the machine. This code allows considerable flexibility and has made possible the construction of simpler arithmetical and control sections. The programmer is not restricted to a small number of predetermined operations, as is the case with more conventional systems, but can construct for himself an almost unlimited number of operations (actually 2^{15}).

A range of basic programmes have been devised and the company claim that they can train a man of Higher National Certificate standard to operate the computer in three weeks. The computer is said to be suitable for use as the nerve centre of a data processing system—again by virtue of the flexibility of coding that allows

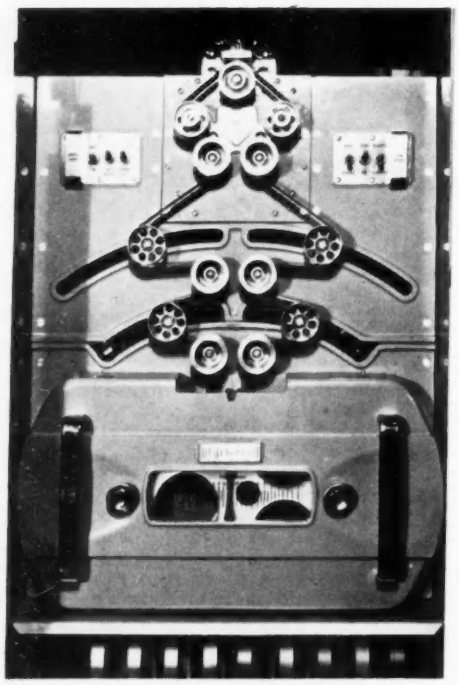
the availability of instructions for the operation of external equipment. The electronic units are mounted on plug-in boards, and both vacuum tubes and semiconductor devices are used. Several research laboratories on the Continent have placed orders for this computer, the largest number going to the Netherlands.

AUTOMATIC ACCOUNTING

On the stand of the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, another digital computer was displayed. The Metrovick 950 is a general purpose model notable for the extensive use it makes of transistors to replace valves. The first model, completed some months ago, is now in experimental use in the company's electronics department. It is suitable for a wide variety of problems in research and engineering design. The table gives its principal characteristics, and it is shown on page 637. Of the further computers of this type now being built, one is for use in the Metrovick research department at Trafford Park and another for the A.E.I. research laboratories at Aldermaston.

A digital computer designed for use in accounting systems was displayed by the National Cash Register Company, Limited, Marylebone-road, London, N.W.1. The computer, the National-Elliott 405 is manufactured by Elliott Brothers and marketed by National Cash. Although there are close links between National Cash of Britain, National Cash of America, and the Underwood Corporation, the 405, is British built and does not use imported American methods. The computer is somewhat larger than the two previously mentioned and incorporates nickel delay lines for working storage. One of the chief points that the manufacturers draw attention to is its unit by unit expansibility. The equipment is designed so that extra memory units, in the form of magnetic film, may be added as the need arises. It is in accounting that extra large memory units are required, since there are generally a very large number of figures upon which fairly simple arithmetical operations must be performed. The increase in storage capacity achieved by use of magnetic film is quite appreciable. Whereas the conventional magnetic drum stores about 4,000 "words," the film stores 300,000.

In practice the conventional adding or accounting machine is coupled to a tape-perforating punch. As the wages data for the current week (basic data only) are entered via the adding machine keyboard on to the employee's history card, the tape punch automatically transcribes the data on to punched tape so that the information may be processed by the computer. The appropriate programme for the computer is selected and the P.A.Y.E. calculations can be rapidly made. In addition to these and similar payroll calculations, the machine can be used for costing, production planning, machine loading, invoicing, billing, dividend writing, premium renewal warrants, inventory controls, budget comparisons and similar analyses of data. It has been announced that orders for these machines approaching one million pounds have been received. A recent installation is at Norwich where the system is used to calculate rate demands. In this case details of 9,000 properties are contained on each 1,000 ft. reel of film and altogether there are some 30,000 properties to be processed. During the course of the financial year the films are processed each week to record details of transactions that occur.



When computers are used for accounting, a large amount of data must be stored. A magnetic film unit such as this can increase the storage capacity of a computer by 300,000 words per reel.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

MAIDSTONE
Annual General Meeting. Kent Branch. Royal Star Hotel, Maidstone. Thurs., May 23, 7.30 p.m.

OXFORD
"Applications of the Cathode-Ray Tube," by C. H. Gardner. Oxford, Reading and Districts Branch. Regents Park College, Pusey-street, Oxford. Sat., May 25, 6.30 p.m.

SOUTHAMPTON
"Sound Recording on Tape and Disc," by J. F. Doust. Southampton Branch. Polygon Hotel, Southampton. Thurs., May 23, 8 p.m.

British Institute of Management

LONDON
"Planning Wide-Range Production for Fluctuating Demand," by T. P. Child. Fyvie Hall, Polytechnic, Regent-street, W.1. Wed., May 22, 6.30 p.m.

British Institution of Radio Engineers

LONDON
"Barium Titanate and Its Uses as a Storage Device," by G. Campbell. London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., May 22, 6.30 p.m.*

Building Centre

LONDON
Films on the construction of wharves and reservoirs, exhibited by Richard Costain Ltd. Wed., May 22, 12.45 p.m.
Films on wood supplies, exhibited by the Timber Development Association. Wed., May 29, 12.45 p.m.

Combustion Engineering Association

SHEFFIELD
"The Production of Fuel Oils, Their Delivery, Storage and Preparation for Burning," by T. Marsden, at 11 a.m.* "Fuel Oil Firing for Furnace Work," by T. Chippindale, at 2.15 p.m. Northern Region. Grand Hotel, Sheffield. Wed., May 29.

Incorporated Plant Engineers

BIRMINGHAM
Brains Trust Meeting to discuss general engineering problems. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., May 31, 7.30 p.m.

Institution of Civil Engineers

LONDON
Discussion on the "Report on the Development of Hydro-Electric Power in the Soviet Union." Joint Meeting with the Institutions of Electrical and Mechanical Engineers. Mon., May 20, 5.30 p.m.*
"Brick and Masonry Arch Bridges: an Investigation," by C. S. Chettoe and William Henderson. Structural and Building Division. Tues., May 21, 5.30 p.m.*
"Portishead 'B' Power Station, with Particular Reference to the Circulating Water Works," by H. D. Morgan and Louis Sancha. Works Construction Division. Tues., May 28, 5.30 p.m.*
"The Regimen of the Thames Estuary as Affected by Currents, Salinity and River Flow," by Sir Claude Inglis and F. H. Allen. Maritime and Waterways Division. Thurs., May 30, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Discussion on the "Report on the Development of Hydro-Electric Power in the Soviet Union." Joint Meeting with the Institutions of Civil and Mechanical Engineers. Institution of Civil Engineers, Great George-street, Westminster, S.W.1. Mon., May 20, 5.30 p.m.*
Annual General Meeting and Film Evening. London Graduate and Student Section. Mon., May 20, 6.30 p.m.*
"Voltage Performance of Series Capacitors in Transmission and Distribution Lines," by J. M. Magowan (to be read by L. L. Langton). Supply Section. Wed., May 22, 5.30 p.m.* Institution's Annual General Meeting (Corporate Members), at 5.30 p.m.* "General Applications of Digital Computers," by Dr. A. D. Booth, at 6.30 p.m. Thurs., May 23.

GLASGOW
Annual General Meeting. "The Allt-na-Lairige Prestressed-Concrete Dam," by J. A. Banks. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., May 29, 7 p.m. (Tea at conclusion of the meeting.)

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
Annual General Meeting. North East Branch. Crown Hotel, Clayton-street, Newcastle-upon-Tyne. Fri., May 24, 6.15 p.m. (To be followed by the annual dinner at 7.30 p.m.)

Institution of Locomotive Engineers

DONCASTER
"Locomotive Feedwater Treatment," by J. S. Hancock and A. J. Parsons. North Eastern Centre. Danum Hotel, Doncaster. Thurs., May 23, 6.45 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on the "Report on the Development of Hydro-Electric Power in the Soviet Union." Joint Meeting with the Institutions of Civil and Electrical Engineers. Institution of Civil Engineers, Great George-street, Westminster, S.W.1. Mon., May 20, 5.30 p.m.*

CARDIFF
Discussion on the "Report on Engineering Education in the U.S.S.R." South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., May 21, 6.15 p.m.

Institution of Naval Architects

LONDON
"Further Experiments on Sideways Launching—Series 2 and 3," by D. J. Doust and E. MacDonald. Thurs., June 6, 4.45 p.m.*

Institution of Production Engineers

BIRMINGHAM
Day Conference on "Tooling: To-morrow's Production." Opening address to be given by H. Burke. Midlands Region. Botanical Gardens, Edgbaston, Birmingham. Wed., May 22, 10 a.m.

Royal Aeronautical Society

LONDON
"Flight Instruments," by F. W. Meredith. Section Lecture. Tues., May 28, 7 p.m.

Royal Institution

LONDON
"Solar Energy: A Challenge to the Future," by Dr. Harold Heywood. Fri., May 24, 9 p.m.
"How Glue Sticks," by Dr. N. A. de Bruyne. Fri., May 31, 9 p.m.

Royal Meteorological Society

LONDON
Symposia on "Planetary Atmospheres and Convection in Rotating Fluids." Joint Meeting with the Royal Astronomical Society. Royal Astronomical Society's apartments, Burlington House, Piccadilly, W.1. Thurs. and Fri., May 23 and 24, 10.30 a.m. to 6.30 p.m.
Discussion on "Long Waves and Storm Surges." Wed., May 29, 2 p.m to 7 p.m.

Royal Society

LONDON
Discussion on "The Initiation and Growth of Explosion in Solids," to be opened by Dr. F. P. Bowden. Thurs., May 30, 10 a.m.

Society of Industrial Radiology

LONDON
"Investment Castings and Their Inspection," by A. Tomkinson. British Institute of Radiology, 32 Welbeck-street, W.1. Fri., May 24, 7 p.m.

Society of Instrument Technology

LONDON
Annual General Meeting. Address by Sir Harold Hartley, G.C.V.O., who has accepted the presidency of the Society. Manson House, Portland-place, W.1. Tues., May 28, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institute of Management, Management House, 8 Hill-street, London, W.1. (GROsvenor 6000.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Combustion Engineering Association, 6 Duke-street, St. James's London, S.W.1. (WHItehall 5536.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Society of Industrial Radiology, 2 Tomswood-terrace, Barking, side, Essex. (HAInhault 5488.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)

In Parliament

CLEAN AIR COUNCIL

The constitution of the Clean Air Council was set out in an Order laid before Parliament last week by Mr. Henry Brooke, the Minister of Housing and Local Government. The Order provided that the Parliamentary Secretary to the Ministry of Housing and Local Government and the Parliamentary Secretary to the Ministry of Power were to be the vice-chairmen.

Among the 29 persons who have accepted invitations to serve on this newly-established body may be mentioned Sir Hugh Beaver, K.B.E., M.I.C.E.; Sir Josiah Eccles, C.B.E., M.I.C.E., M.I.E.E., deputy chairman, Central Electricity Authority; Mr. C. S. Garland, M.I.Chem.E., President, National Union of Manufacturers; Lord Dudley Gordon, D.S.O., Past-President, Institution of Mechanical Engineers; Mr. R. W. Husband, A.M.I.H.V.E., controller of engineering department, Beecham Group Limited; Sir Henry Jones, M.B.E., M.I.C.E., M.Inst.Gas E., deputy chairman, Gas Council; and Professor M. W. Thring, F.Inst.P., F.Inst.F., Department of Fuel Technology and Chemical Engineering, University of Sheffield.

STEEL FOR BUILDING

A plea was made by Mr. Cyril Osborne (Conservative) for the replacement of the steel used in building construction by reinforced concrete. He pointed out that such a course would save large quantities of steel for export and that many responsible architects felt that steel was being wastefully buried in new buildings.

Mr. Hugh Molson, the Minister of Works, stated that licences were no longer required for steel for building, but a very rough estimate of the amount of steel used in that way last year was 1¼ million tons. Reinforced concrete was a well-established method of construction. It was the method generally adopted for Government buildings unless there was a good reason to the contrary. During the year ended June 30, 1956, about 160 framed buildings of all types were designed by the Ministry of Works, and no fewer than 110 of them were constructed in reinforced concrete.

In the case of the second half of the new Government building in Whitehall-gardens, London, it had been decided to use reinforced concrete instead of structural steel. There would be a saving of £130,000 as a result.

INQUIRY INTO WAGES AND PRICES

A statement was invited by Mr. Frederick Lee (Labour) from Mr. Iain Macleod, the Minister of Labour and National Service, regarding the suggestion of the court of inquiry into the disputes in the engineering and shipbuilding industries that an authoritative and impartial body should be set up to consider the wider implications of the movement of wages, costs and prices. He pointed out that, if such a body were to be formed, a great deal of its success, or otherwise, must depend upon the interpretation which the Government put upon its impartiality. For instance, if the inquiry were to be merely an inquisition into wages, it could hardly be expected to receive full co-operation from the trade unions. If, on the other hand, there were to be a genuine effort to look at profits and the general economic situation, as well as at wages, then many members on the Labour side, Mr. Lee considered, would hope for a really fruitful culmination of the suggestion for an inquiry.

Mr. Macleod said that he welcomed the suggestion to which Mr. Lee referred. Such a proposal involved discussions with both sides of industry and the Government were giving urgent consideration to the form which a body of that kind might take and the scope of its terms of reference. He fully appreciated what Mr. Lee had said. It was exactly to those aspects that the present conversations were being directed.

It was suggested by Mr. Ellis Smith (Labour) that, if the report of the court of inquiry were successful in bringing about an interim settlement of the dispute, the time had arrived when a long-term settlement should be reached, and that the Minister should use his influence to that end. Mr. Macleod said that, of the three recommendations put forward by the court of inquiry, the first was on wages, the second on the National Joint Council, and the third on the setting up of the impartial body to which reference had been made. The first two items were essentially matters, at the moment, for the parties to the dispute, and he did not propose to go into them unless the negotiations collapsed. The setting up of the impartial body did require Government action. The talks on this subject now proceeding were informal but it was hoped that more formal discussions would eventuate.

Answering a point raised by Mr. Joseph Grimond (Liberal), the Minister said that he did not wish to be too precise at the moment as to what subjects might be investigated by the proposed impartial body, because these matters were forming the basis of the present discussions. He had in mind, however, that the new body would take the form of a standing organisation and not merely one to conduct a once-and-for-all inquiry.

£55 MILLION OVERDRAFT

The total of the overdrafts of the nationalised industries has been reduced from £123 million on August 15, 1956, just prior to the first advances by the Treasury, to £55 million on April 17 last. The latter figure, Mr. Peter Thorneycroft, the Chancellor of the Exchequer, told Mr. Grimond, represented the extent of the industries' current short-term need. Mr. Thorneycroft added that he could not make a statement at present about the Government's intentions with respect to the financing of the nationalised industries after the expiry of the Exchequer's lending powers in March, 1958. The overdraft was limited to their short-term needs, as was the case in industry generally.

ACCIDENTS IN CIVIL ENGINEERING

The high rate of accidents in the building and civil-engineering construction industry, referred to by the Chief Inspector of Factories in chapter 10 of his report for 1955, formed the subject of questions by Mr. John Rodgers (Conservative). He asked the Minister of Labour what action was being taken and urged that, since most of the firms in this industry employed only 20 men, or even fewer, the interests of these small firms should be kept clearly in mind. Mr. Robert Carr, the Parliamentary Secretary to the Ministry of Labour and National Service, replied that the Minister of Labour had increased the staff of the factory inspectorate and had decided to set up an advisory committee, under his (Mr. Carr's) chairmanship, representative of the organisations primarily concerned. It was hoped that the committee would stimulate interest in these industries in problems of safety and health, with a view to reducing the incidence of accidents and health hazards. He agreed with the remarks of Mr. Rodgers about small firms. If progress was to be made in these matters, it was necessary to arouse the active interest of both sides of the industry.

CONVERTING COAL-FIRED POWER STATIONS TO NUCLEAR ENERGY

Mr. Albert Roberts (Labour) referred to Mr. Reginald Maudling's "declared intention of building only nuclear-energy electricity-generating stations after 1970" and asked what consideration had been given to the technical possibilities of converting coal-fired plant to the use of nuclear energy, as this coal-fired plant became obsolete. Would the Paymaster-General, Mr. Roberts inquired, be prepared to set up a committee to inquire into the technical possibilities of such a conversion? Mr. Maudling replied that conversions of the kind referred to were not at present a practical proposition, but they constituted a possibility which would be kept under constant review.

He did not think that there was any need for a committee as the United Kingdom Atomic Energy Authority had the matter very much under consideration. The problem at present confronting the scientists concerned was that the temperature and pressure of the steam in conventional and nuclear power stations were very different, but, with the technical developments taking place on the nuclear energy side, conversions might become possible. Mr. Maudling emphasised that no decision had yet been taken to cease building conventional power stations after 1970, or any other date.

Technicians in the Coal Industry

According to an answer given by Mr. Reginald Maudling, the Paymaster-General, to Sir Alfred Bossom, Bt. (Conservative), the number of technical employees in the coal industry has considerably increased over the past two years. Mr. Maudling stated that the number of draughtsmen had risen from 1,200 in September, 1954, to 1,300 in September, 1956; the number of technical coal workers from 11,200 in September, 1954, to 12,800 in September, 1956; and the number of clerical employees from 28,000 in September, 1954, to 31,900 in September, 1956.

Surplus Coal Stocks

Mr. Maudling told Mr. R. Moss (Labour) that, on April 20, 16·5 million tons of coal were held in distributed stocks and that 3·7 million tons remained in hand. Mr. Moss observed that miners in the Warwickshire Coalfield and, he believed, elsewhere, were becoming increasingly alarmed at the visibly growing stocks of surplus coal, in spite of assurances given by the National Coal Board to the National Union of Mineworkers. He asked Mr. Maudling to tell the miners that there was no danger of their having to work short time owing to the stocks of coal in hand. Mr. Maudling stated that the stocks existed because of the mild weather. No one in the industry need be concerned in any way.

Government Grants to Universities

A suggestion was put forward by Mr. Fred Mulley (Labour) that the Minister of Education should appoint a working party to review the system, and the amount, of grants to British universities. Sir Edward Boyle, Bt., the Parliamentary Secretary to the Ministry of Education, said that the Minister, Lord Hailsham, was aware of the recent proposals to this effect, but he could not make a statement at present. The triennial review of the amounts of university awards would be held during the coming autumn, and any changes would be brought into effect in 1958.

Science Teachers from the Forces

Sir Edward Boyle told Mr. I. J. Pitman (Conservative) that Lord Hailsham hoped that suitable officers and other ranks leaving the Forces would become teachers, particularly of mathematics and science. Arrangements already existed for training those older students among the Forces personnel who possessed special qualifications.

Taking Work in Another Area

Details of a new scheme for assisting the temporary transfer of workers from areas where there is a redundancy of labour of a non-permanent character were given by Mr. Macleod in reply to a question by Miss Elaine Burton (Labour). He said that the scheme applied to employees who had been out of work for at least eight weeks, for whom there was no early prospect of obtaining suitable employment locally, and who continued to maintain dependents at home. Such workers who, from June 11 onwards, with the prior knowledge of the Ministry's local office, took up employment beyond daily travelling distance, for which no suitable local unemployed worker was available, would be eligible to receive a free fare, a lodging allowance for a period of up to twelve months, and facilities to enable him to return to the home area to obtain employment there. The rate of lodging allowance would be 35*s*. a week.

THE HUMAN ELEMENT

Spring Lift to Employment

During April the percentage of unemployment fell from 1·7 to 1·6 compared with March. This represents something of a seasonal improvment but the comparison with April, 1956, is slightly unfavourable. At that time the unemployment percentage was 1·2. That a good deal of the improvement was due to seasonal factors can be seen from the fact that agriculture, fishing and building gained labour and this was to some extent at the expense of engineering and the foodstuffs industries as well as the distributive trades.

On the other hand it is significant that the percentage of unemployment in the Midlands has fallen below the national average. The difference is only slight (the Midlands percentage in April was 1·5) but it has been in this area that the brunt of the unemployment consequences of the credit squeeze have been felt. Meanwhile the pressure of unfilled jobs on the labour force is rising—a tell-tale sign of incipient inflation if it gets out of hand. The rise is most noticeable in the London area which is always slightly ahead of the rest of the country in letting demand run ahead of supply in the labour market.

Wages Court Attacked

The inevitable has happened, with very little delay. The recommendations of the Court of Inquiry for an impartial authoritative body to investigate wages policy in its widest setting have received the heaviest of broadsides from the National Union of Railwaymen. An editorial in their official journal, the *Railway Review*, makes it plain that unions can have no truck with a body which, if successful, would take bargaining away from wage negotiations. It is, in their view, a direct and dangerous attack on the power of the trade unions which should be resisted at all costs. The N.U.R. warn that "if the Government are foolish enough to force it they will be in for trouble."

Few trade union leaders look upon the wages court proposal with any sympathy. However much they feel that some planning is required to fashion an orderly and sensible wages structure out of the current chaos, none will admit that to leave such matters to the jurisdiction of a court is practical politics. The Court of Inquiry probably realised that such opposition was likely, and a more acceptable formula may therefore be ready to hand.

There is a strong case for such a body, of proven impartiality and with the ability to study in the most comprehensive manner the structure of wages and salaries. It is difficult to conceive an alternative—except continued chaos and lost time.

Transferring the Unemployed

The Ministry of Labour's temporary transfer scheme for the unemployed redundant was announced last week. It is notable for its careful system of checks and balances rather than for a bold and imaginative approach. It will come into operation on June 11 this year. The scheme will apply to workers who have been unemployed for at least eight weeks, for whom there is no prospect at once of suitable local employment and who continue to maintain dependents at home. These workers must take up employment beyond daily travelling distance for which no suitable local unemployed worker is available and the whole exercise must be carried out with the prior knowledge of the Ministry of Labour's local office. A lodging allowance of 35*s.* per week for up to twelve months is available.

For those men who are prepared to put up with petty administration there is a good deal to be said for this arrangement. For the man who has enough drive and energy to get on with the job of finding alternative employment, there is now an added incentive to look after himself.

Women to Teach Technology

Addressing the recent North London Productivity Committee's Conference Sir Edward Boyle, Parliamentary Secretary to the Ministry of Education, suggested that there might be more women employed to teach technical subjects especially in the technical colleges. He was dealing with the well known fact that there is an opinion that a large wastage of woman power in gainfully employed occupations occurs during the child-bearing and family-rearing years. He argued that industry might consider taking on more women with the right qualifications and that these might do a certain amount of part-time teaching while raising families. This would give the technical colleges the benefit of the women's experience while they were in industry and would provide teaching staff at a point where there was likely to continue to be an acute shortage for some time.

The idea is attractive if the initial problem of prejudice against women in technical jobs can be more widely tackled, for if Sir Edward Boyle's idea were to work the women would first have to be acceptable to industry to get their basic training. Prejudice against women in industry is an amalgam of several things. Some of it is certainly male prejudice, some of it misplaced doubts about women's ability to keep their emotions out of their work, and a good deal of it the general experience of a high wastage in industry in a time of full employment when the average marriage age for women is lower than it used to be.

No Holds Barred

Peace is slow to return to the shipbuilding and engineering industries. The reports of the Courts of Inquiry suggested a novel approach to old problems, embodying the germ of a lasting solution. Yet they have failed to provide the easy solution to recent disputes that had been expected. The unions had clearly been expected to accept the suggestion of an 11*s.* a week rise together with certain conditions laid down by the employers, including a wages standstill for twelve months. The alternative was an 8*s.* 6*d.* rise (5 per cent.) with no strings attached.

The principle of conditional increase in wages fared badly at the conference held by the union's leaders last week to discuss their attitude at their meeting with the employers' representatives. The president of the Confederation of Engineering and Shipbuilding Workers, Mr. H. Brotherton, moved that the meeting should empower their representatives to go forward with a free hand to negotiate the best settlement they can get. Mr. W. J. Carron, president of the Amalgamated Engineering Union, moved an amendment, that the representatives should press for an increase of not less than 11*s.* a week and for elimination or modification of the conditions for such an increase. This amendment was defeated, and the Confederation's resolution carried. The union leaders now go forward with no guidance other than to get the best they can out of the employers, and to report back to the Conference before any settlement is accepted.

The debate over the A.E.U. resolution was unusually acrimonious. Mr. Carron sustained his first major defeat from the left of the movement. The outcome is now uncertain but the possibility of a further open conflict cannot be excluded.

Freedom to Design

How is the able young engineering designer to be early detected and encouraged? This is an awkward question, for a middle course must obviously be steered between encouraging the younger men and wasting large sums of money and time on useless design projects. The problem has been recently tackled by a report called "The Technical Education of Engineering Designers," submitted by a committee to the Council of the Institution of Engineering Designers.

It accepts that it is difficult to encourage original thought on design since companies can rarely afford to give freedom of expression to anyone but heads of design departments. The present technical education system has been reviewed and, assisted by a questionnaire to members, certain subjects pin-pointed which have been neglected hitherto; examples are heat treatment, fatigue and stress concentration, corrosion problems, protective treatment, environmental problems and testing. Emphasis is laid on syndicate work for designers at college as is often organised for laboratory work. The report also considers that more attention should be given to design failures as well as successes. "Sandwich" courses are recommended in place of single day or evening classes at colleges. There are also views expressed about the shortage of teachers.

Unions and Office Workers

The renewed attempts by the National Union of Bank Employees to get wage negotiating machinery organised with the banks is a reminder of the sharp cleavage between employers and trade unionists about organising office workers. The trade unions naturally look forward to the time when all sizeable groups of workers, irrespective of their kind of job, will carry a union card. The employers shrink from the prospect of union representatives being able to use concessions obtained from factory operatives as a means of getting similar gains for clerks—and vice versa. The ring has been held by the white-collar workers themselves who cling to the mild snoberies of another age.

Engineering itself has a vital interest in the problem for it percolates through to the estimating office, the cost office and even to the drawing office. In the last case there has been such a shortage of skilled men that terms of employment have rather kept ahead of any gains that formal negotiations by groups could achieve. This is probably the answer to the situation. When skills are scarce (as with draughtsmen and good clerks) individuals can do better for themsleves than can professional negotiators. Where there is less scarcity or men cannot move easily from job to job (as happens with bank clerks) the long run favours organised bargaining from the clerks point of view. For employers, therefore, the answer must be to keep ahead of the field and thereby remove temptation from clerical labour when next the union organiser calls round.

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An unusual case of mis-reporting followed the Classical Association's annual dinner last month and found its way into these columns ("Latin for the Engineer," April 26). Professor J. B. Skemp, speaking in defence of Latin, urged that it should be included in a broader and better balanced curriculum for grammar schools up to ordinary level at least. The word "drama" was substituted for "grammar"—taking the argument for a broad education perhaps a little further than had been intended!